OLOGY DEPARTMENT

March 1947

TECHNOLOGY REVIEW

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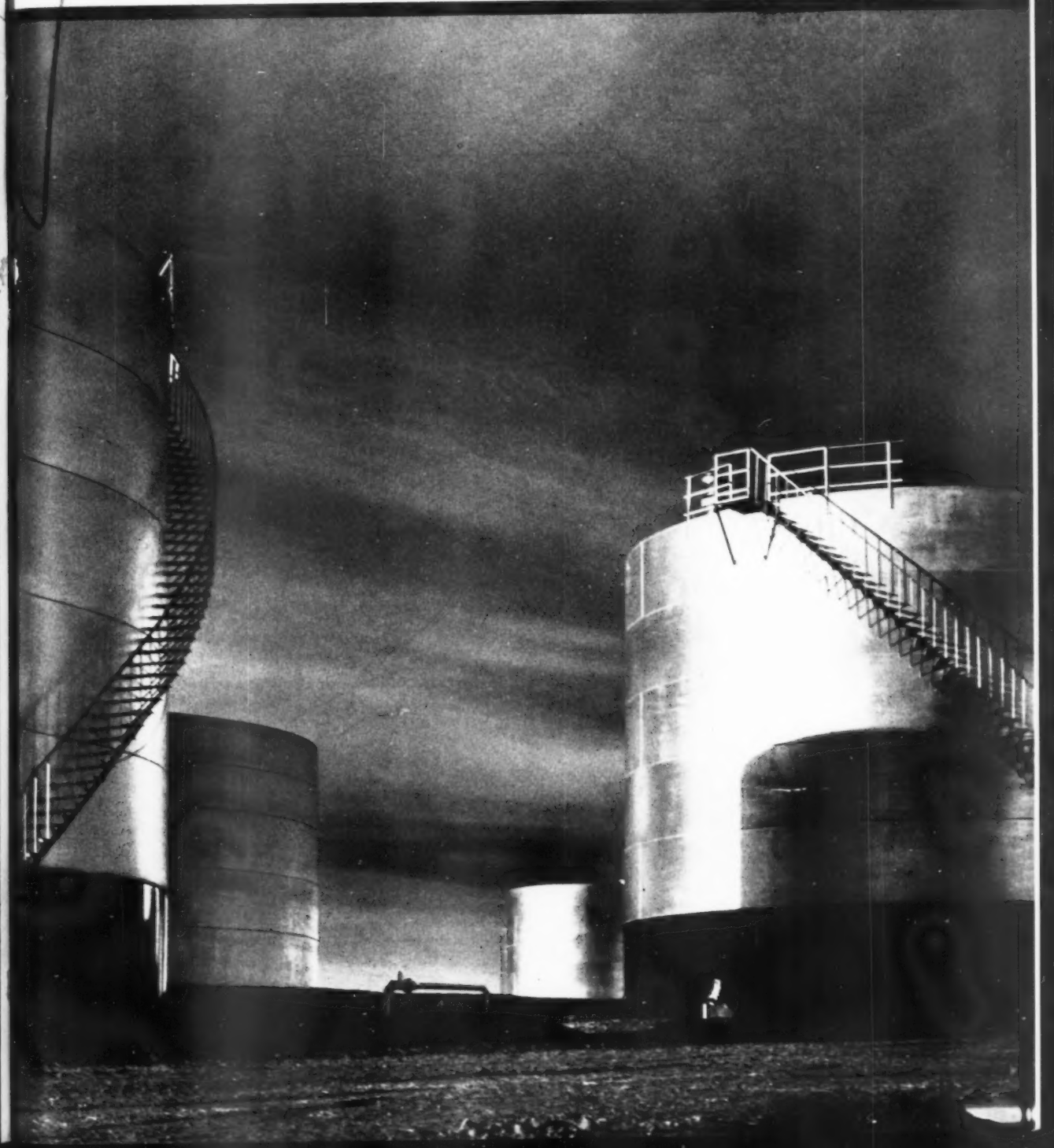
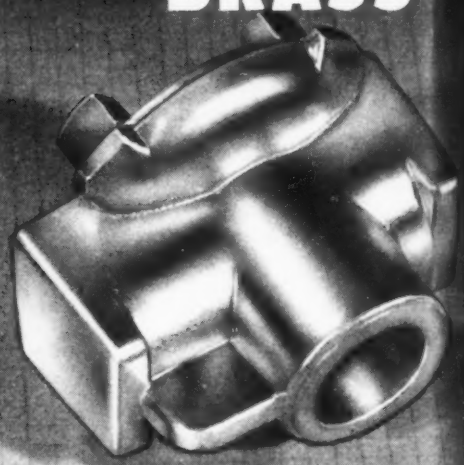
DETROIT

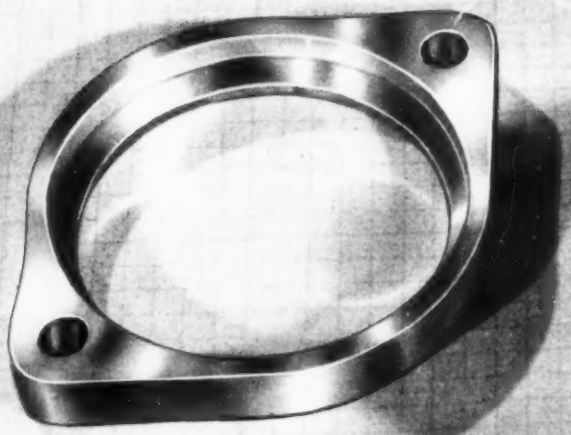


ALUMINUM

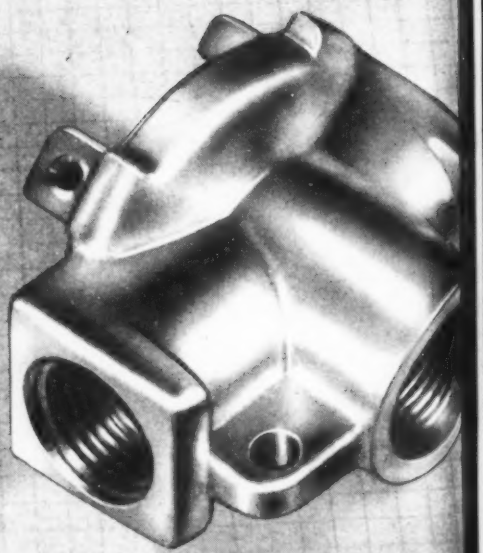
BRASS



SMOOTH FORGED



MACHINED



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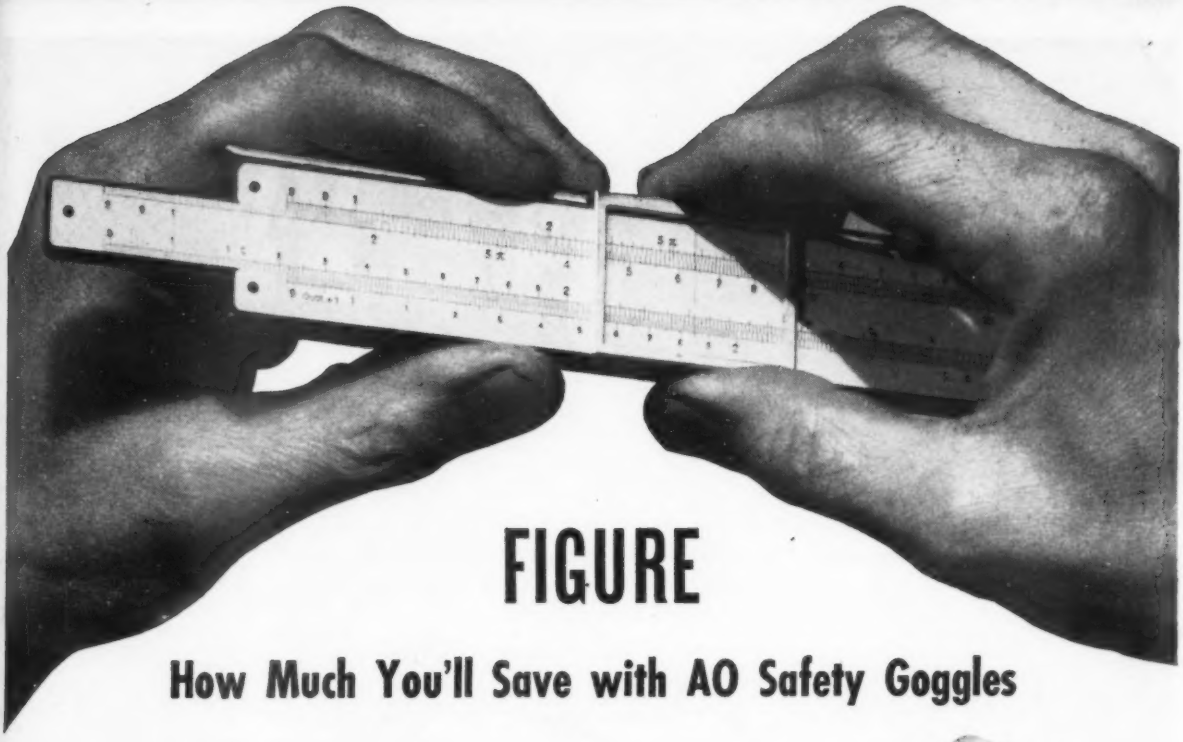
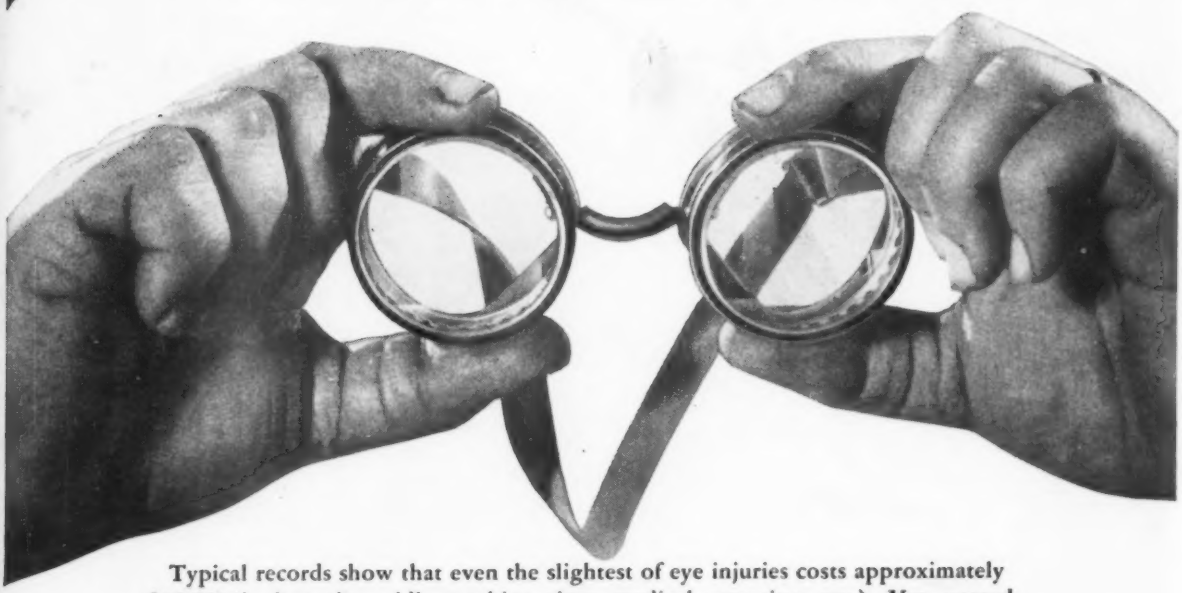


FIGURE

How Much You'll Save with AO Safety Goggles



Typical records show that even the slightest of eye injuries costs approximately $15.00 (in lost time, idle machine time, medical attention, etc.). Yet, according to the Society for the Prevention of Blindness, *98% of all eye injuries can be prevented by the use of safety goggles.*

AO Safety Goggles are saving sums like these: a manufacturer of electrical equipment —$14,000 in two years; a large machinery maker—$44,000 annually. And in most instances entire eye protection programs pay for themselves in six months to a year.

Why not look at your own eye injury costs, and figure what an adequate eye-protection program would save. As a help in figuring send for a copy of the new booklet "Eye Accident Costs."
Write to Box T.

American Optical COMPANY *Safety Division*

SOUTHBRIDGE, MASSACHUSETTS. OFFICES IN PRINCIPAL CITIES

THE TECHNOLOGY REVIEW, March, 1947. Newsstand Edition. Vol. XLIX, No. 5. Published monthly from November to July inclusive at 10 Ferry Street, Concord, N. H. Publication date: twenty-seventh of the month preceding date of issue. Annual subscription $3.50; Canadian and Foreign subscription $4.00. Entered as second-class matter at the Post Office at Concord, N. H., under the Act of March 3, 1879.

SOON . . . THE NEW NATIONAL NC-173

The NC-173 is the wholly new product of months of post-war research, prompted by war-time advances in radio technique.

Utilizing 13 tubes in a superheterodyne circuit, the NC-173 offers an RF amplifier stage, separate AVC amplifier, voltage regulator for circuit stabilization. A wholly new concept in noise limiter design makes "double-action" noise limiting equally effective for both phone and CW.

Its tuning system offers new flexibility through tuning capacitors connected in parallel on all five bands. Its frequency range covers not only 540 to 30 MC. but also the 6-meter amateur band.

Smart styling and outstanding performance are characteristics you'll note in this newest member of the National family. At your dealer's soon.

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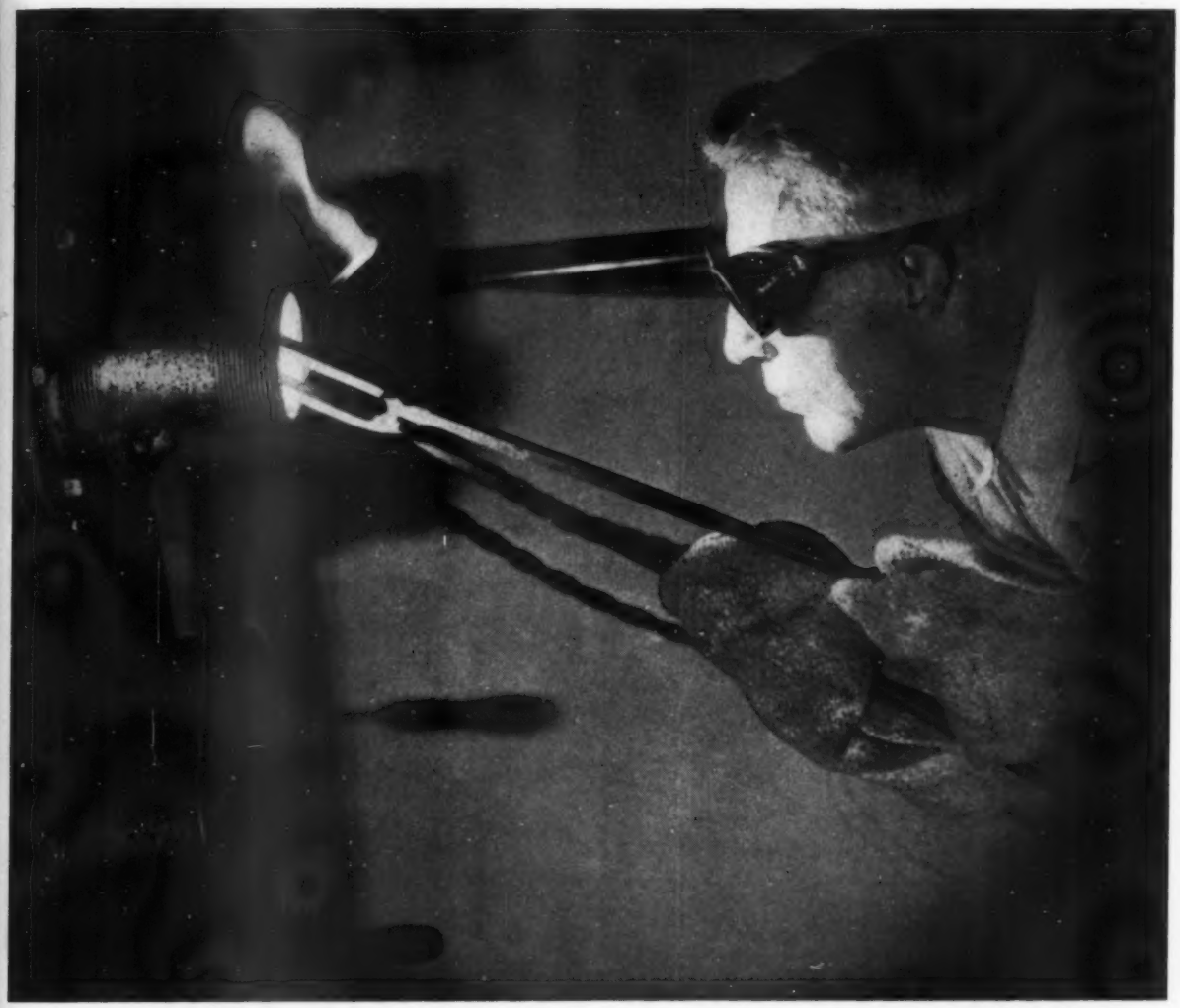
MALDEN, MASS.

THE MOST DISTINCTIVE NAME IN RADIO COMMUNICATIONS



Norton Refractory Tubes are able to withstand high temperatures and to give long, economical service in a variety of furnace operations. For special, high temperature work we recommend our new "Pure Oxide Refractories". ALUNDUM* furnace tubes, which are sintered alumina without any bond, do provide greater refractoriness and much longer life. Thereby they greatly extend the utility of the furnace tube line of Norton Refractories.

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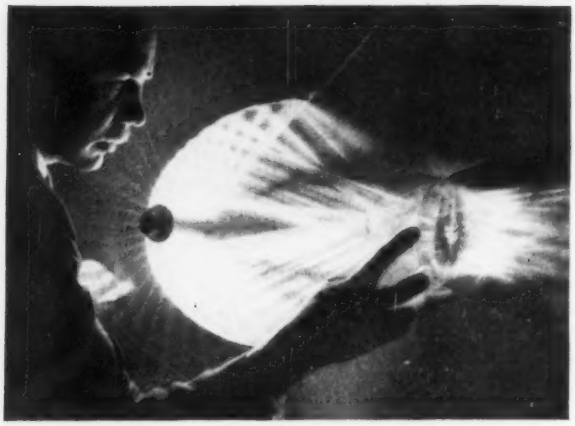

BRINGING NEW IDEAS TO YOU...

from the Laboratories of General Electric

IN THEIR work in the General Electric Flight Test Laboratory, people like Girl-Engineer Marguerite Hartl, shown above, are bringing nearer the day when you will fly in planes powered with gas turbines. Once used only in fast jet-propelled fighters, G-E gas turbines like the Propjet will soon fly commercial airliners and perhaps your own sports plane . . .

Safer lighting of streets is a never-ending search in the company's Illuminating Engineering Laboratory. Lighting Specialist Hal Breeding studies the light pattern of a reflector on test . . .

The day may not be far off when snowclouds may be forced to drop their snow over ski slopes rather than over your city. Vincent J. Schaefer of the G-E Research Laboratory can change real clouds as well as laboratory ones into snow . . .

These are three of the many hundreds of men and women who work in the 29 G-E laboratories to make new ideas serve you. Some, like Mr. Schaefer, seek fundamental truths for science. Others, like Mr. Breeding, work to ***apply*** these truths in the making of better products. Still others, like Mrs. Hartl, study and test G-E products, the materials that go into them and the machines by which they are made.

With the help of this large and well-equipped laboratory team, General Electric carries further its basic aims . . . to make jobs secure and profitable for its workers, to gain a fair return for its stockholders, and to make new and better products for the public.

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Products of the Cabot group of enterprises meet many of the essential needs of American industry. One of these products is Pro-Vitamin A, for the fortification of foods and feedstuffs. Another is Chlorophyl, a coloring agent for soaps and other products. Still another use for Chlorophyl, in an entirely different field, is in the manufacture of air wicks. Chlorophyl also has very definite therapeutic values.

For the rubber industry, Cabot is the world's largest producer of SRF Carbon Black. Yet SRF Black is but one of the forty-one distinct grades of this important raw material produced by the Cabot organization for the rubber, ink, paint, varnish and lacquer industries.

All maintain the same high characteristics. In the manufacture of Carbon Black by the Channel process, for instance, Cabot established the standards by which all other Channel Blacks are judged. Emphasis always is on sustained high quality in all of the diversified Cabot production schedules.

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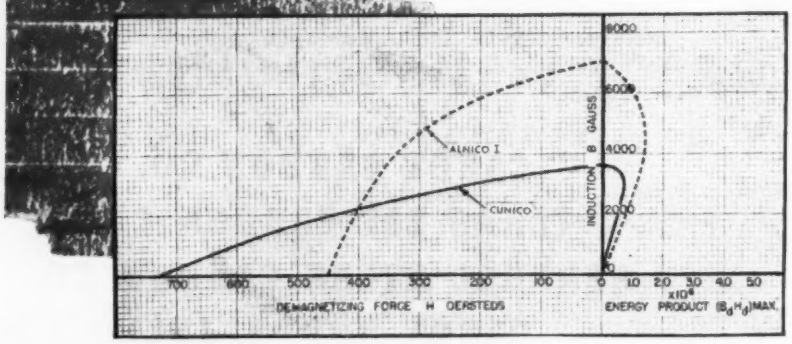
Cunico can be magnetized in any direction, and is most efficient where a large cross section is available to produce sufficient total flux. Generator rotors are a typical application. A relatively short length is required to maintain the flux because of its high coercive force.



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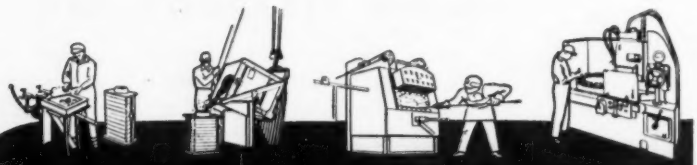

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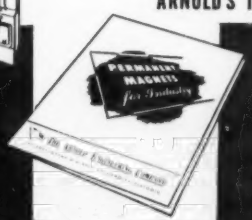

ARNOLD'S TECHNICAL BULLETIN

"Permanent Magnets for Industry" suggests many ways in which the war-born improvements in permanent magnets can be most valuable to you. Send for it!

how to braze 18 pieces into 6 units *in 7 Seconds*

Cutting costs by reducing assembly time is a neat trick . . . and here's how you can do it with induction heating.

The normal method of flame brazing this three-piece, steel tube assembly did as well as any other technique then available. But production was pitifully slow. It took minutes to complete one entire unit.

By designing a jig like the one shown above, a simplified, efficient system was found to do the job. The fixture held 6 complete units (18 separate pieces) in place firmly while a standard Westinghouse 20-kw generator brazed all six uniformly in 7 seconds! Final operation was so simple a girl could easily handle the assembly and brazing.

The beauty of electronic heating is its unmatched ability to do all types of heat-treating jobs quickly . . . annealing, hardening, sintering, soldering, curing, bonding and molding. Ask your Westinghouse office today for all the facts on induction heating and where it fits your operations. Or write Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Penna. J-08143

Here's Helpful Information on both induction and dielectric heating . . . their principles and theories; where to use them; how to select them; actual case histories of their use. Write for your copy today. Ask for B-3620.

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Electronics at Work

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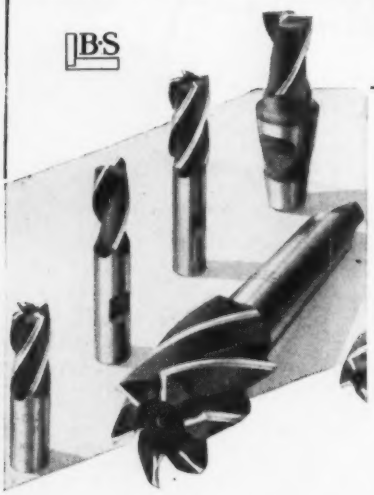

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Surges Transformers

With the acquisition of the Surges Electric Company of Milwaukee, Hevi Duty can now offer quality dry type air cooled transformers with or without tap changing switches as well as special transformers for special requirements. An accelerated program of modernization will present opportunities for increased production and good delivery schedules.

Write for Bulletin S-4611

HAROLD E. KOCH '22, *President*

ELTON E. STAPLES '26, *District Manager, Cleveland*

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THE TABULAR VIEW

Watery Chorus. — Turning from geophysical prospecting to oceanic prospecting during the war, MILTON B. DOBRIN, '36, gives an excellent account (page 271) of noises produced by a large number of species of fish, shrimp, and other aquatic inhabitants. That such research was an important, if somewhat unexpected, necessity during the war may be surmised when it is realized that about the only way a submarine commander gets information from outside his ship's submerged hull is by underwater sound equipment. When a hydrophone picks up strange sounds, it is highly important to know whether they are caused by enemy ships, submarine mines, or lowly fish. Currently on leave of absence from the Naval Ordnance Laboratory to continue his graduate studies at Columbia University, Mr. Dobrin has written a number of articles which have appeared in The Review.

Nocturnal Survey. — Example of peacetime research applied to problems of warfare is given by PROFESSOR HAROLD E. EDGERTON, '27, who recounts for us (page 273) the military applications of electric-flash photography for night aerial reconnaissance. His article portrays an excellent example of the co-operation of sciences to achieve a desired goal; for aeronautical engineering, photographic engineering, and several branches of electrical engineering combined to adapt radar and electric-flash techniques to the problem of ferreting out what the enemy does at night. Dr. Edgerton, whose doctoral thesis on the hunting of synchronous motors led to the development of electric flash and stroboscopic light sources, has long been known as an authority on photographic techniques with microsecond exposures.

Blessed Sleep. — Frequent contributor to The Review, DR. TENNEY L. DAVIS, '13, turns from the chemistry of explosives to present an able, historical account (page 279) of the discovery of anesthesia, first publicly demonstrated in Boston's Massachusetts General Hospital a bit over a century ago. Included in Dr. Davis' survey are comments on the historical documentation of this famous discovery as recorded in recent publications. Dr. Davis' retirement from the professorship of organic chemistry at M.I.T. in June, 1942, has not curbed his activities. Between 1941 and 1943 he produced three volumes on *The Chemistry of Powder and Explosives* and now directs research for National Fireworks, Inc.

On the Other Foot. — The self-criticism which we directed at ourselves during the war in sometimes providing too little equipment too late, seems to have afflicted the Germans as well as the Allies. At least, this is the case with some of the guided missiles which were in the development stage when the war ended, as confirmed in the article by WILLY LEY (page 281). Distressing as are these grim developments, they serve as reminders of the alternatives of failure of the peace treaties now processing. Mr. Ley is well known to Review readers not only as a writer on topics of science and engineering but as a research worker at the Washington Institute of Technology.

IT TAKES MORE THAN MUSCLE

According to legend, Polydamas, the Greek athlete, killed a lion with his bare hands, stopped a chariot in full flight, and lifted a raging bull off the ground with ease. His career, however, came to a spectacular end when he tried to catch a huge falling rock.

Today, sudden, heavy loads end the life of many steel parts. Low temperatures, for instance, can have a depressing effect on the impact strength of steels. Molybdenum steels, which combine deep hardening and freedom from temper brittleness, reduce this risk.

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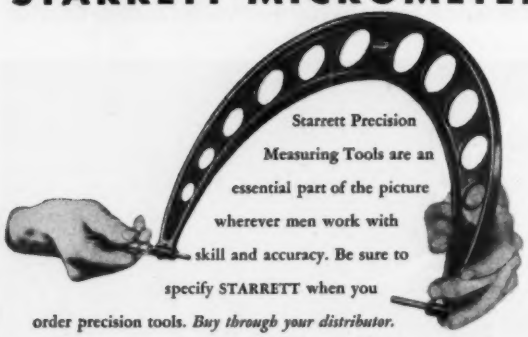

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When the problem before you requires precision gearing—it's a job for Diefendorf. Diefendorf's long reputation for precision manufacture assures top performance and a long useful life. Every Diefendorf Gear is engineered for its particular job.

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MAIL RETURNS

Origin of the Lathe

FROM C. J. LEBEL, '26:

I believe that your editorial "Prospect and Retrospect" in the January, 1947, issue got off to a doubtful start by crediting the invention of the lathe to David Wilkinson in 1797.

The lathe was invented centuries before David Wilkinson's time, and the patent which prompted your comment covers the slide rest. However, it would appear that the slide rest much precedes Wilkinson's work, since it was pictured in French encyclopedias of 1717 and 1772. And the slide rest of today is credited as a lineal descendent of the work of Henry Maudslay by the authority J. W. Roe in Chapter I of his classic *English and American Tool Builders* (Yale University Press). *New York 25, N. Y.*

A Problem in Rapid Descent

FROM HOWARD M. EDMUNDS, '05:

A few years ago you ran a feature in which "teasers" were set for solution by your readers. I am therefore emboldened to ask the solution to the brachistochrone problem for a specific set of conditions.

Point A is located on a vertical wall 16 feet high, whereas Point B is in a horizontal direction 32 feet from the foot of the wall. I shall be greatly obliged if you would show how to find the curve of quickest descent of a frictionless bead, sliding by gravity from A to B, and also give the total time of descent. The stumbling block in the brachistochrone problem is the determination of the integration constant.

The bibliographies available from sources at my disposal seem to give no solution for a specific case. I have hunted in four languages (including Latin) for a solution as applied to a specific case, but so far without success.

In connection with the difficulty occasionally encountered in finding a specific solution for a problem whose general solution is known, it is interesting to note that, under the subject of Curves, the *Encyclopedia Britannica* states that although Newton gave the correct answer to the problem set by Bernoulli and Leibnitz in about 1700 A.D., it took the mathematical world until about 1850 to determine that there is only one cycloid which answers for any assigned set of conditions.
New York 28, N. Y.

Although Mr. Edmunds has obtained the solution to his problem since the above communication was written, his letter is presented for the benefit of those Review readers who might like to try their hand at an interesting mathematical pastime. — Ed.

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Alfred T. Glassett '20, Vice President

"Wisdom must be intuitive reason combined with scientific knowledge"

—ARISTOTLE (DIALOGUES)

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THE TEMPTING FOODS spread before the family of today are more nourishing and purer than ever before.

All the way from farm to table, *modern means of food preservation* protect foods against damaging molds, bacteria, insects—against loss of nutrients.

Chemical refrigerants preserve meat . . . nitrogen gas safeguards the purity of canned foods . . . ethylene oxide and "dry ice" protect wheat before it is milled . . . stainless steel tanks prevent contamination of foods and beverages . . . and plastics line many food containers.

Food preservation has become an industrial science—and well illustrates the fact that when man has better materials he can do better things.

Producing better materials for the use of industry and the benefit of mankind is the work of UNION CARBIDE.

Basic knowledge and persistent research are required, particularly in the fields of science and engineering. Working with extremes of heat and cold, and with vacuums and great pressures, Units of UCC now separate or combine nearly one-half of the many elements of the earth.

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OUTSTANDING PROPERTIES OF *SANDEE* ETHYL CELLULOSE

1. *Specific Gravity* —*1.14*
2. *Tensile Strength* —*Excellent*
3. *Impact (high & low temps)* —*Excellent*
4. *Heat distortion* —*170—185°*
5. *Rigidity* —*Good*
6. *Dimensional Stability* —*Very Good to Excellent*
7. *Burning Rate* —*Slow*
8. *Odor* —*None to very slight*
9. *Color* —*Unlimited*
10. *Finish* —*High Gloss if Desired*

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Sandee ETHYL CELLULOSE *Extrusions*

THE excellent dimensional stability and low temperature impact strength of Ethyl Cellulose successfully filled many rigid war-time requirements in injection molded parts. However, to meet peacetime requirements, higher rigidity and greatly improved finish had to be added to the above properties. Sandee, with the full cooperation of material suppliers, can now offer either high gloss or semi-gloss finish extrusions of excellent rigidity and dimensional stability. Rods, tubes, simple and complicated shapes in this excellent modern material can be extruded to meet your exacting requirements. If an extruded plastic can serve, by all means take advantage of our newly enlarged facilities and all the skill and experience of our plastic engineers.

ELMER SZANTAY, General Manager, '35

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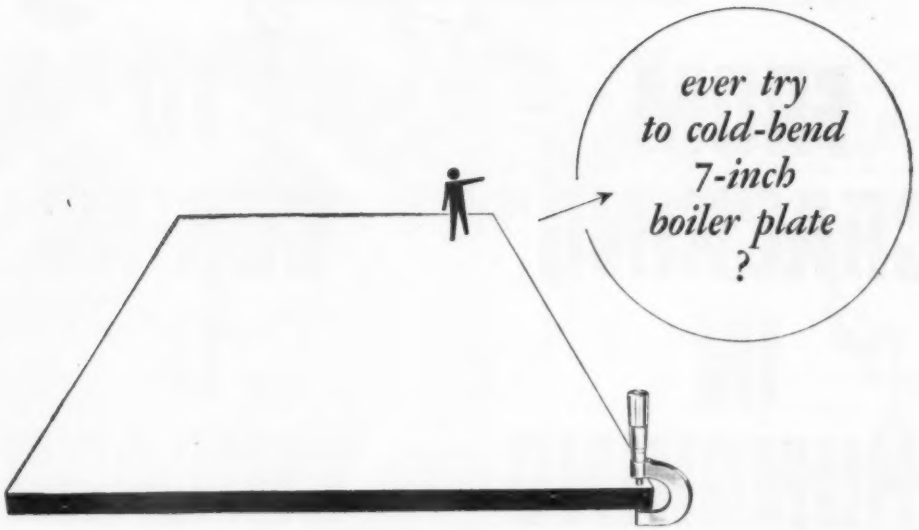

These three factors are the unwritten plus-values in every C-E contract —

Knowledge

— to solve today's, and tomorrow's, steam generating problems.

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— to interpret, from a world-wide background in every important industry, the specific needs of each installation.

Facilities

— to manufacture complete steam generating units for every requirement, from 30 boiler horse power up to the largest.

IT requires a pressure of about 6000 tons. We can do it with the largest boiler plate bending press in America.

This giant press is 55 feet wide and 49 feet high (27 feet above ground and 22 below). The tremendous pressure exerted by it is needed in the final stages of forming heavy plate, where cold-bending eliminates warping and permits finishing to very close tolerances.

So far we haven't had to cold-bend 7-inch boiler plate, present commercial limits being slightly over 5 inches, but to be *able* to do so is a not-unusual example of C-E facilities. In the 60 acres of C-E plants you will find specialized equipment for every manufacturing requirement — some of it as spectacular as this 6000-ton press.

This has importance for you. It means that the exact needs of your installation can be met without compromise — that C-E knowledge and experience is backed by complete manufacturing facilities for every required type and capacity of steam generating unit above 30 boiler horse power.

B-110

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Many Lummus-built plants have established records for *long initial runs* — the forerunners of *outstanding performance in the long run.*

Whatever direction your refinery plans are taking, Lummus has the know-how — plus the laboratory, pilot-plant, engineering, and construction facilities — to help translate them into profits. Lummus engineers will appreciate an opportunity to discuss the desirability of studying your refinery, to determine what modernization or expansion will be necessary to meet tomorrow's market requirements.

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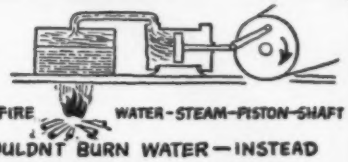
2



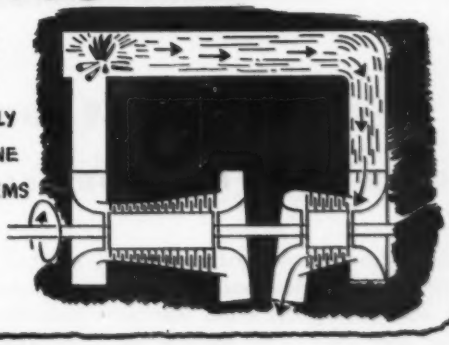
FIRE COULDNT BURN WATER—INSTEAD IT CHANGED IT TO STEAM. SO MAN HARNESSED STEAM, USING FIRE INDIRECTLY TO PUSH A PISTON—TURN A WHEEL AND SHAFT....

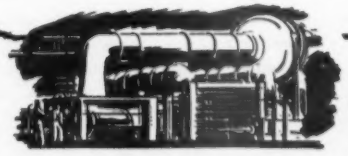
3 FIRE-PISTON-SHAFT··

INVENTION OF THE INTERNAL COMBUSTION ENGINE ELIMINATED STEAM AS A LINK···BROUGHT FIRE CLOSER TO THE CRANK··· BUT THE FRICTION OF RECIPROCATING MACHINERY STILL LOSES POWER··· CAUSES WEAR.

4 THE GAS TURBINE··

NOW, IN THE GAS TURBINE, FIRE IS APPLIED DIRECT TO THE SHAFT. A COMPRESSOR SUPPLIES AIR TO THE COMBUSTION CHAMBER. FUEL BURNER HEATS AIR, GREATLY INCREASING ITS VOLUME. HEATED AIR RUSHES THROUGH TURBINE AND TURNS SHAFT. SOUNDS SIMPLE BUT MANY TOUGH PROBLEMS OF DESIGN AND METALLURGY HAD TO BE SOLVED TO MAKE IT PRACTICAL.....





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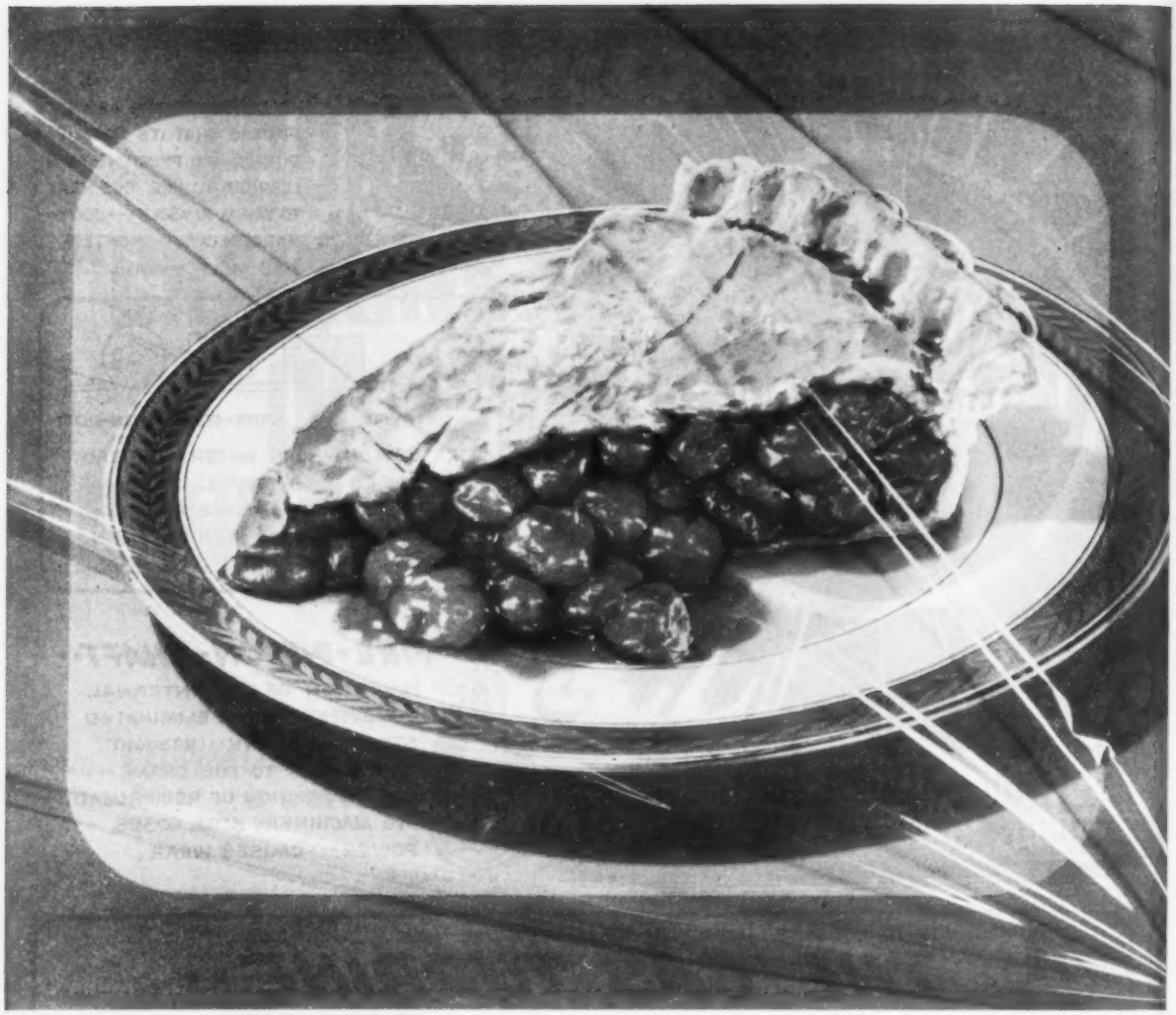

Pie crust makes its "film" debut

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VOLUME 49 NUMBER 5

THE TECHNOLOGY REVIEW

TITLE REGISTERED U. S. PATENT OFFICE

EDITED

AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Photo by H. Armstrong Roberts

"Science; Hmmpf!"

CONTENTS for MARCH, 1947

THE COVER — OIL TANKS
From a photograph by Partridge from Black Star

HYDROPONICS — SOILLESS GROWING OF PLANTS — FRONTISPIECE 266

PISCATORIAL CONCERTO — BY MILTON B. DOBRIN 271
Caused Concern of Many a Submarine Commander during the War

NIGHT AERIAL PHOTOGRAPHY — BY HAROLD E. EDGERTON 273
Becomes an Indispensable Tactical Device When Aided by Radio Navigation

A CENTURY OF SLEEP — BY TENNEY L. DAVIS 279
Adds New Luster to the Consequences Adhering to a Great Event

TOO FEW, TOO LATE — BY WILLY LEY 281
Is the Story of Some of Germany's Guided Aerial Missiles

☆ ☆ ☆

THE TABULAR VIEW 256
Contributors and Contributions

MAIL RETURNS 258
Letters from Review Readers

THE TREND OF AFFAIRS 267
News of Science and Engineering

THE INSTITUTE GAZETTE 283
Relating to the Massachusetts Institute of Technology

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Hydroponics — soilless growing of plants

THE
TECHNOLOGY
REVIEW

Vol. 49, No. 5 March, 1947

The Trend of Affairs

"Get It!"

MARCH 3 marks the centenary of the birth, in Edinburgh, Scotland, of Alexander Graham Bell, whose invention of the telephone opened a new era in private communication. Under the stimulating influence of his father, Alexander Melville Bell, a well-known teacher of speech and phonetics, young Bell had been interested from early youth in phonetics, speech, and acoustics, and began his career as a teacher of deaf mutes. The Bell family moved to Tutelo Heights near Brantford, Ontario, Canada, in 1870 but another migration was soon in store for young "Aleck." Upon invitation of the Board of Education of Boston to make experiments in the city school for deaf mutes, Bell first arrived in Boston on April 1, 1871, and took up permanent residence in Boston and its environs on October 1, 1872. Two years later, on October 27, 1874, while residing in Salem with the grandparents of one of his pupils, Bell declared his intention to become a United States citizen.

Although the musical sounds produced by electric telegraphs interested him greatly, Bell's early experiments were directed to means for improving the telegraph rather than toward devising an electrical method of reproducing speech. In this country, Bell's vibrating reed telegraph has now developed into the vast Bell Telephone System, and telephonic communication with persons in all parts of the civilized world is possible. With assets of more than $6,500,000,000 in 1944, the Bell System is the second largest corporation in America.

Proponents of the theory that technology increases unemployment may be reminded that in 1945 some 459,000 persons were employed to maintain 110,700,000 miles of wire lines and to operate the 27,867,000 telephones in the United States where 54 per cent of the world's telephones are installed. During 1945, the last year for which accurate figures are available, 36,800,000,000 telephone calls were made at the rate of 284.4 conversations per capita per year.

From the vantage point of a century later, it is not easy to recognize the difficulties which stood in the way of electrical transmission of speech in 1847, or even 25 or 30 years later, when Bell's work was first crowned with success. But the history of the telephone, and particularly its very early history, is of all-embracing interest to Review readers, not alone because the telephone was developed in Boston, but also because Bell had friends among the Faculty and carried out early researches in acoustics at the laboratories of the Massachusetts Institute of Technology, which was just rounding out its first decade of educational service.

At a time when his invention was not quite yet an instrument for satisfactorily conveying speech, Bell found a supporter in John D. Runkle, Professor of Mathematics from 1865 to 1902, and from 1868 to 1878, Acting President and President, respectively, of the burgeoning Institute. Edward C. Pickering, Professor of Physics and Director of the Rogers Laboratory of Physics at M.I.T. from 1867 to 1877, offered encouragement and the Institute's laboratory facilities to Bell.

But it was with Charles R. Cross, '70, Professor of Physics from 1871 to his retirement in 1917, that Bell had most contact. It was probably Cross, founder of the Institute's Department of Electrical Engineering in 1882, who showed Bell the Institute's model of the not-too-successful telephone of Reis and who helped Bell in certain experiments in acoustics. Charles A. Morey, a student at Technology from 1872 to 1874, devised the improved form of the phonautograph, an early type of oscillograph, used in these experiments. Late in 1874 Bell described his method of transmitting articulate speech electrically to a number of persons including the 27-year old "Professor Charles R. Cross, of the Institute of Technology, Boston." Both Cross and Pickering testified for Bell in the patent suit brought by the United States against Bell in the spring and summer of 1892, during which an unsuccessful attempt was made to show that Bell was not the inventor of the telephone.

International News Photo

At the White House on January 20, President Truman expressed the nation's thanks to a group of scientists for their work in directing the country's scientific man power and research facilities during the war. Seated, in reading order, are: James B. Conant, President of Harvard University and Chairman of the National Defense Research Committee; President Truman; and Alfred N. Richards, Vice-president in charge of medical affairs, University of Pennsylvania, and Chairman of the Committee on Medical Research. Standing are: Karl T. Compton, President of M.I.T. and member of the National Defense Research Committee; Lewis H. Weed, Director of the Johns Hopkins Medical School, and Vice Chairman of the Committee on Medical Research; Vannevar Bush, '16, President of the Carnegie Institution of Washington, and Director of the Office of Scientific Research and Development; Frank B. Jewett, '03, President, National Academy of Sciences, and member of the National Defense Research Committee; Jerome C. Hunsaker, '12, Chairman, National Advisory Committee for Aeronautics, and member of the Advisory Council of the Office of Scientific Research and Development; Roger Adams, Head of Chemistry Department, University of Illinois, and member of the National Defense Research Committee; A. Baird Hastings, Harvard University, member of the Committee on Medical Research; and Alphonse R. Dochez, Columbia University, member of the Committee on Medical Research.

On May 25, 1876, Bell, who held the post of Professor of the Mechanism of Speech at Boston University, read a paper describing his work "before the 197th Meeting of the Society of Arts, held in the Massachusetts Institute of Technology, in Boston, Mass." It was primarily his experiments, however, that aroused the interest of his colleagues at Harvard as well as at the Institute. On April 20, 1877, after he had demonstrated the telephone at the Philadelphia Centennial, a committee of distinguished men wrote Bell, "confident that the general public of the city in which your researches have been made will be glad to witness a practical exhibition of your telephone under your direction, respectfully request that you gratify this desire of your fellow-citizens at such time and place as may be most convenient to you." This invitation was signed by notables of the time including Harvard's Benjamin Peirce, Professor of Astronomy and Mathematics, Henry W. Longfellow, Professor of Belles-lettres, Oliver Wendell Holmes, Professor of Anatomy, and Charles W. Eliot, President, of Harvard University; William F. Warren, President of Boston University; and Technology's John D. Runkle and Edward C. Pickering, soon to become director of the Harvard Observatory. In response to this invitation Bell gave three lectures in Boston's Music Hall on May 4, 7, and 8, 1877.

It would be pleasant to be able to record that the Institute had a greater claim to the development of the telephone in its early stages. The facts appear to be, however, that Bell's work at the M.I.T. laboratories was limited to experiments in acoustics and did not include electrical experiments. During the 1892 suit Bell stated: ". . . the professors of the Institute of Technology always extended to me the greatest courtesy and placed all their apparatus at my disposal for any experiments I desired to make. So far as I remember, however, the investigations I desired to make at the Institute of Technology, and did make, had reference mainly to the use of the manometric capsule and the phonautograph of Léon Scott, as improved by Mr. Morey of the Institute of Technology."

Judged by modern standards, how quaint was Bell's training for his important work in electricity! Speaking of his education, and particularly of his acquaintance with electricity, Bell remarked: "I rather think the books I used were such as I could pick up at old bookstores. I do not mean to say that it may not be possible that I may have read some of the textbooks on physics . . . but I cannot assert so positively. My knowledge of electrical subjects was not acquired in a methodical manner, but was picked up from such books as I could get hold of, and from such experiments as I could make with my own hands."

In the middle of the Nineteenth Century it was possible for a painter to devise an electric telegraph, and for a teacher of phonetics to evolve a means of reproducing the spoken voice. A century ago, a sufficient amount of hard work and determination might have substituted for academic training, but even then the limitations of the brute force method were recognized.

In a letter to his parents, dated March 18, 1875, Bell tells of a meeting he had with Joseph Henry, Secretary of the Smithsonian Institution, and recounts the interest displayed in telephone experiments by "the Tyndall of America." Bell writes: "I felt so much encouraged by his interest that I determined to ask his advice about the apparatus I had designed for the transmission of the human voice by telegraph . . . I said that I recognized the fact that there were mechanical difficulties in the way that rendered the plan impracticable at the present time. I added that I felt that I had not the electrical knowledge necessary to overcome the difficulties. His laconic answer was, 'Get it.' . . . I cannot tell you how much these two words have encouraged me."

Liquid Diet for the Iron Horse

RETIREMENT, as a result of old age, appears to be an early prospect for the smoke-emitting, puffing iron horse. For more than a century it has played a spectacular and pictorial role in this nation's development. Its popularity, long at a high level, probably reached its apex when the first transcontinental railroad was completed on May 10, 1869, with the joining of the Union Pacific and the Central Pacific rails at Promontory Point near Ogden, Utah. As might be expected, there were speeches and ceremonies marking the occasion, and Leland Stanford, President of the Central Pacific, was already looking forward to the time when "three tracks will be found necessary to accommodate the commerce and travel which seek a transit across this continent."

But today's modern pace is too much for the lineal descendants of the *DeWitt Clinton* and the *Tom Thumb*. Continually puffing and out of breath, the steam locomotive of the middle Twentieth Century has developed other signs of senility; it now shows increasing signs of distressing stomach ulcers. The transformed chlorophyll, taken from the mines of Pennsylvania, Illinois, or West Virginia, is too indigestible for the aging locomotives. To be sure, coal never was completely digestible, as the billowing clouds of black smoke reminded us decade after decade. The soot and grime of rail centers have become increasingly annoying, costly to remove, and harmful.

For relatively short hauls between metropolitan centers in well-settled portions of the land, the iron horse first gave way to the electric locomotive, whose diamond-shaped pantograph or smoothly polished shoe took power from an overhead line or a third rail. Within the last decade, the supremacy of the steam locomotive has been increasingly threatened by the sleek, aerodynamically designed, silver-trimmed Diesel locomotive. Today the iron horse, like the buffalo which it drove from the plains decades ago, is itself threatened with extinction. Efficiency, economy, and ease of operation are the principal factors for the rapid rise of Diesel locomotives but other factors have also contributed to the retirement of steam engines. Not the least of these have been strikes in the coal mines which, with increasing frequency and seriousness of consequences, have disrupted rail service, or threatened to do so. Each new strike only served further to emphasize the need to change the sustenance of the iron horse from a solid to a liquid diet.

In 1935 the production of steam locomotives led that of the Diesels by four to one. Today, however, the situation is quite different, for only five per cent of the orders for new locomotives are for the coal-burning steam variety, and the Diesels have the field pretty much to themselves. Even this five per cent would seem to be but a symbolic "whistling in the dark" for it is reported that orders on the books for steam locomotives come from those railroads which derive most of their freight revenue from coal haulage.

The extent to which Diesels are replacing steam locomotives is dramatically brought out by recent statements

The dramatic history of railroads is pictorially portrayed in this unusual illustration of five Illinois Central locomotives. Probably unintentionally so, the overhead feeders symbolize the replacement of solid fuel-consuming locomotives by more efficient engines. Will the youngsters of tomorrow look upon such scenes as this with the same historic perspective as we regard paintings of yesterday's clippers?

Photo by Kaufmann and Fabry Co.

of John W. Barriger, 3d., '21, President of the Chicago, Indianapolis, and Louisville Railway, popularly known as the Monon Line. In a sense, serving as a proving ground for others to follow, the Monon is equipping all of its trains with Diesel locomotives.

All in all, the indications are that the beloved, snorting, puffing, smoke-belching iron horse, which once was undisputed master of long distance transportation, will soon take its place along with the square-rigger, side-wheeler, and horse-drawn carriage as a nostalgic symbol of more leisurely days.

Lysozyme

LYSOZYME is an enzyme found in particularly high concentration in two widely different sites, the whites of hens' eggs and the tears of human eyes. Occurrence of an identical substance in two such apparently unrelated biological fluids is rationalized by the function of lysozyme, which is to destroy bacteria by "lysing" or dissolving the bacterial cell wall. In the egg, lysozyme combats bacteria that penetrate the shell from the outside after the egg is laid, and thus protects the developing embryo during hatching. Likewise, lysozyme helps to postpone spoilage of eggs when man diverts them from their original function of reproducing chickens and uses them as food. In human tears, lysozyme similarly aids in protecting the relatively exposed and delicate eye tissues against bacterial invasion.

The two primary sources of lysozyme, egg white and tears, are both animal in nature; but recently an enzyme having lysozyme activity has also been isolated from a plant source, the latex or sap of Central American trees of the *Ficus* genus. However, this plant lysozyme differs chemically from lysozyme of animal origin. In *Ficus* trees the function of lysozyme has not been established; it may act, like animal lysozyme, as an antibiotic to protect the plant against invading organisms, but it might also be a metabolic agent to break down by lysing certain nutrients, similar to the polysaccharides of the bacterial cell wall that enter into the metabolism of the tree.

It has been suggested that the potentialities of lysozyme for use as a clinical antibiotic, like penicillin, be explored. This would represent a new approach to control of infection, differing not only from antibiotics, such as penicillin or streptomycin that are secretions of one type of microorganism used to combat another microorganism, but also differing from preparations like antitoxins and serums that are produced by the mammalian blood stream to combat an actual infection. If lysozyme should prove useful as a clinical antibiotic, immediate practical application could be made of a recent isolation of lysozyme in pure crystalline form. Lysozyme, like other enzymes and also like the vitamins, was recognized initially by its biological activity, and was studied for a long time in mixed preparations before separation in pure form. Such isolation, now accomplished, lays the groundwork for establishment of the chemical nature of lysozyme, which in turn opens the way to its chemical synthesis. Synthesis is an important step in wide practical application of any biological substance of clinical value, since manufacture by snythesis is usually more productive and cheaper than preparation from biological sources.

500,000,000 Cavities

FOR more than a decade it has been known that the presence of one or two parts of fluorine per million parts of drinking water markedly reduces the amount of tooth decay. Larger fluorine contents lead to a characteristic tooth mottling. It is believed that in many areas, such as the noted Deaf Smith County of Texas, the inhabitants owe their dentist-defying molars to the presence of this element in the water supply.

The suggestion is now advanced that a reverse condition may also exist; the presence of specific chemicals in the water accelerating dental decay. As evidence, the results of a dental survey of two groups of towns in southern New Jersey are brought forth. One group of towns depends on deep wells tapping the Raritan strata, the water containing from 1.4 to 2.2 parts per million of fluorine. The children of these towns require substantially less dental care than normal, and, at a given age level, the longer their stay in these towns, the lower their rate of dental attack.

Two nearby towns also use a fluid called water, which is described as "acid enough to require treatment with alkali," containing "excess iron to the extent that aeration is required to remove it," and carrying "an unusually high content of nitrates." In these towns a directly opposite trend was observed. Not only was the general level of dental caries higher, but the longer a migrant stayed in this area, the more vulnerable to decay his teeth became.

If these findings are substantiated, and if tests now being conducted on the controlled addition of fluorine to water supplies work out as planned, there exists a tremendous field of application. It was recently stated before a meeting of New York dentists that the teeth of the American public currently contain about 500,000,000 cavities, with more than a hundred million new ones being added every year. To carry out the necessary repair and maintenance work on all these teeth is quite beyond the capacities of this country's dentists, even if the public had the necessary time and desire to do so.

The Noble Stinkwood

THERE was a time in this country when a farmer who had a fence, log cabin, or old barn made of red cedar owned a valuable property. The red cedar forests of our southern states were being exhausted, and American manufacturers of lead pencils considered this wood as the only suitable material. Later it was found that the western incense cedar had much the same characteristics, but in the meantime, many a structure built of red cedar had been torn down for conversion into wooden pencils.

A somewhat similar situation now exists in South Africa, where the stinkwood tree, a plant of quite moderate stature as trees go, and outwardly of less than overwhelming appearance, is in strong demand for furniture and decorative purposes. The cutting of these trees from public forests has been forbidden for about a century. A large tree in private hands is said to bring as much as £1,000; a cubic foot of wood will bring as much as four pounds. In the face of such prices, farms are being combed for old wagons, fences, and other structures made of stinkwood (more sweetly known as South African Oak).

Piscatorial Concerto

If, as Submarine Commander in Japanese Waters during the War, You Picked up Unaccountable Underwater Noises at Close Range, Would You Welcome the Babel of Singing Fish?

By Milton B. Dobrin

THE time was the second April Fools' Day after Pearl Harbor. The place was a conference room in the Navy Building at Washington. Thirty civilians and 20 naval officers were discussing a subject which, offhand, might have appeared a fitting one for the day but scarcely a proper one for the Navy, especially in wartime, for conversations were largely centered about the noisemaking characteristics of fish and other forms of marine life.

Nevertheless, the matter was one of very considerable importance to the Navy because noise from fish had recently been found to interfere with the effective operation of the underwater listening devices being used to protect harbors from sneaking enemy craft and to detect enemy submarines at sea. Moreover fish noises threatened to cause premature firing of the acoustic mine mechanisms which the Navy was beginning to use. The purpose of the April 1 conference was to review all that was known about the noise made by fish and Crustacea and to lay out a program of further investigation on the subject. With more knowledge of their habits and the nature of the noise they produced under different conditions, it appeared probable that effective countermeasures to the obstructionism of Pisces might be devised.

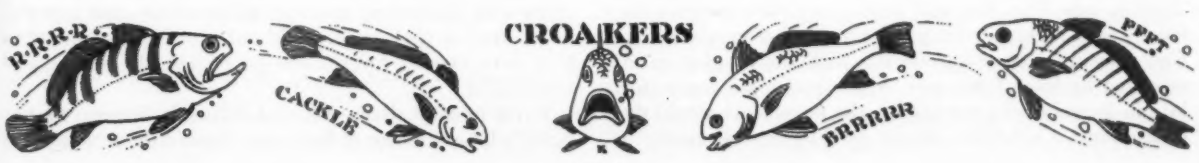
As a result of this meeting, a number of expeditions were organized to conduct a systematic study of fish noises along both the East and West Coasts of the United States, as well as in the South Pacific and the Caribbean region. These expeditions provided excellent opportunity to listen to and record sounds which, although common enough in the underwater world, had seldom been heard by human ears.

The fact that many fish make noise underwater has long been common knowledge to most fishermen, at least to those working in warm water. Naturalists and ichthyologists have published observations on the subject for more than a century: with a paper on the noise produced by catfish, Louis Agassiz was one of the earliest contributors to knowledge on this subject. Even the names of several common American species, such as the croaker, red drum, toadfish, and hogfish are based on the habit which these fish have of making characteristic noises when pulled out of the water. Vacationers along the bays and sounds of the Carolinas and Virginia, immersing their heads during early evening swims, have heard the fish choruses distinctly without the aid of hydrophones or electronic amplifying equipment. It is said that fishermen of the Mediterranean Sea locate schools of maigre (*Pseudosciaena aquila* one of the drums) by listening for them.

It is, therefore, somewhat surprising that sound men in the armed forces were completely baffled when, five months after Pearl Harbor, hydrophones laid by the Coast Artillery to protect Chesapeake Bay from snooping enemy craft began to yield a strange babel of noises. The sounds resembled a pneumatic drill tearing up asphalt, a steamboat whistle, and the cackle of geese, all at the same time. The noise from ships directly above the 'phones was drowned out completely. After the sound men had checked and re-checked their instruments, they concluded that whatever the weird noises, they were actually in the water and not spurious instrumental effects. The Coast Artillery appealed to the Office of Scientific Research and Development for help, and the O.S.R.D. sent down a party from the United States Navy Underwater Sound Laboratory at New London to listen to the noises. Charles H. Blake, '25, Professor of Biology at the Massachusetts Institute of Technology, was called into consultation and almost immediately identified the major component of the noise as that of croakers, fish which had returned to the Bay with the coming of spring, after having spawned in the open ocean.

Expedition in Search of Noise

The Navy was particularly interested in Dr. Blake's diagnosis because it was at the time developing devices, both of an offensive and defensive nature, which would make use of the sound transmitted underwater from ship and submarine propellers. Among these were acoustic mines, set off under a ship by the noise it generates, listening gear on submarine chasers, and sonic detecting equipment to be used at harbor approaches. Substantial programs to investigate biological water noise were consequently instituted by three Navy research activities. The laboratory at New London and the United States Navy Radio and Sound Laboratory at San Diego were interested in the subject because of its bearing on antisubmarine warfare. The Naval Ordnance Laboratory at



Floating net at Beaufort, N. C., for confinement of fish specimens whose sound is being recorded. The hydrophone is suspended from the near corner of the rectangular frame.

Washington, which designed most of the mines that later blockaded Japan, was interested because it wanted to know what soniferous fish might do to its acoustic mines. Although all of these organizations sponsored numerous expeditions to study fish noises, the present article will deal mostly with the work done by the Naval Ordnance Laboratory, since the author is in a position to describe most of it from experience as an active participant.

Anvil Chorus

The first expedition of the Naval Ordnance Laboratory to obtain data on submarine noise of fish was sent out in the spring of 1942 to measure and record noises made by breakers in the surf off Cape Henry at the entrance to Chesapeake Bay. The surf was readily audible over the hydrophones during the daytime but at night unexpected drilling and rasping noises were picked up which, after conference with the nearby New London party, were attributed to marine life.

It was soon discovered that the peak of the evening noise was reached about 8:30 P.M., at which time the water sounded like a forge shop in full production. This analogy is more than a mere simile because the actual noise level was found to be considerably higher than would be registered by a noise-level meter in a typical forge shop, being of the same order of magnitude as the noise emitted by an airplane motor 15 feet away. After the peak was reached, the level would die away as rapidly as it rose, and long before midnight the water became as quiet as it had been at noon.

There was a pronounced seasonal as well as diurnal effect. The noise was virtually missing during the winter and early spring, when croakers were absent from the bay. Then in late May it would begin, and each evening the level would be higher than the evening before, the variation showing a close correlation with the croaker catch reported by local fishermen. After reaching a maximum late in June (as did the catch), the noise level would decrease until it would be almost gone by mid-summer.

While this work was going on in Chesapeake Bay, a special section was established at the Navy's San Diego laboratory to record noises in the Pacific, particularly off the coast of Southern California. Choruses of croakers were heard here too, but more important to those engaged in the sonar projects at San Diego was the constant crackling noise picked up in shoal waters. After a tireless search, and numerous false leads ranging from oysters to crabs, Dr. Martin W. Johnson, a marine biologist from the University of California, identified the crackling as coming from the snapping shrimp, or *Crangon dentipes*, a tiny crustacean which is highly abundant in coastal warm-water areas the world over. The noise was important in antisubmarine warfare because most of it was found to be in the ultrasonic portion of the acoustic spectrum. Thus it would be likely to interfere with the ultrasonic beams sent out by echo-ranging gear in subchasers, beams which would bounce back again when intercepted by a submarine hull.

All of the observations on biological noise in home waters were interesting and directly useful to the Navy. Even in 1943, however, the observations in domestic waters were not as interesting as information on the noises that might be expected to occur in the East Indies and off the coast of Japan. It was out of the question to send acoustics experts and scientific expeditions into areas to which the sole access was by submarine. The desirability of a comprehensive acoustic survey was indicated, however, by dispatches from a number of our submarine commanders operating in the western Pacific. They reported that, from Borneo to the Marshall Islands, many kinds of clicking, ticking, and droning noises were audible over supersonic listening systems even when no ships were sighted in their periscopes. But such reports, interesting as they were, could not provide the quantitative data needed for the design of acoustic mines and sound gear.

Early in 1943, Rear Admiral Julius A. Furer, '05, the Navy's Co-ordinator of Research (*Continued on page 290*)

Night Aerial Photography

When Radio and Radar Direction-Finding Methods Are Combined with Recent Advances in Night Photographic Equipment Night Reconnaissance Becomes Indispensable

By Harold E. Edgerton

INTEREST in aerial night photography began at M.I.T. quite unexpectedly during the summer of 1939. An unannounced visitor from the Air Forces, who identified himself as Major George W. Goddard of the Photographic Laboratory at Wright Field, came to the Stroboscopic Laboratory and inquired whether the new types of electric-flash equipment then in the development stage could be used as a light source to take photographs at night from airplanes. This potentially new application of flash photography was one to which no serious attention had previously been given because there seemed to be little need for such photography and also because of the considerable weight and bulk of the equipment. Major Goddard thought it might be useful to make photographs from an altitude of a mile or more and asked what help we might be able to render.

A few rough calculations with the inverse square law of light distribution, using the known exposure and weight data for equipment that was modern in 1939, quickly showed that apparatus required to make night photographs at the height of one mile would weigh several tons. Furthermore, the flash lamp would need to be many hundredfold more powerful than any lamp whose construction or design had then been attempted. Our knowledge of almost seven years ago indicated that the required kind of flash lamp could probably be built. But there was also a good probability that the lamp would explode during its first, and only, operation because of the intense heat and high pressure developed when the flash occurred. Even an optimist couldn't feel too encouraged about the prospect of success.

For one concerned with flying, Major Goddard (who bore the title of colonel at the end of World War II) was completely unimpressed by the very considerable weight of nocturnal photoflash equipment. He knew that the new planes, then on the drawing board, would have no difficulty in carrying such heavy equipment, and he offered encouragement and inspiration in the face of other obstacles. Before he left Cambridge, he had committed us to work on the problem and promised that an official request would come through from Dayton.

Thus started a chain of development work which continued until the end of hostilities in August, 1945. By the end of the war, six distinct types of flash photographic units had been perfected for the United States Army and Navy and had seen service on nearly all fronts. They did not represent the first attempts at night aerial photography, however.

Military Need for Night Aerial Reconnaissance

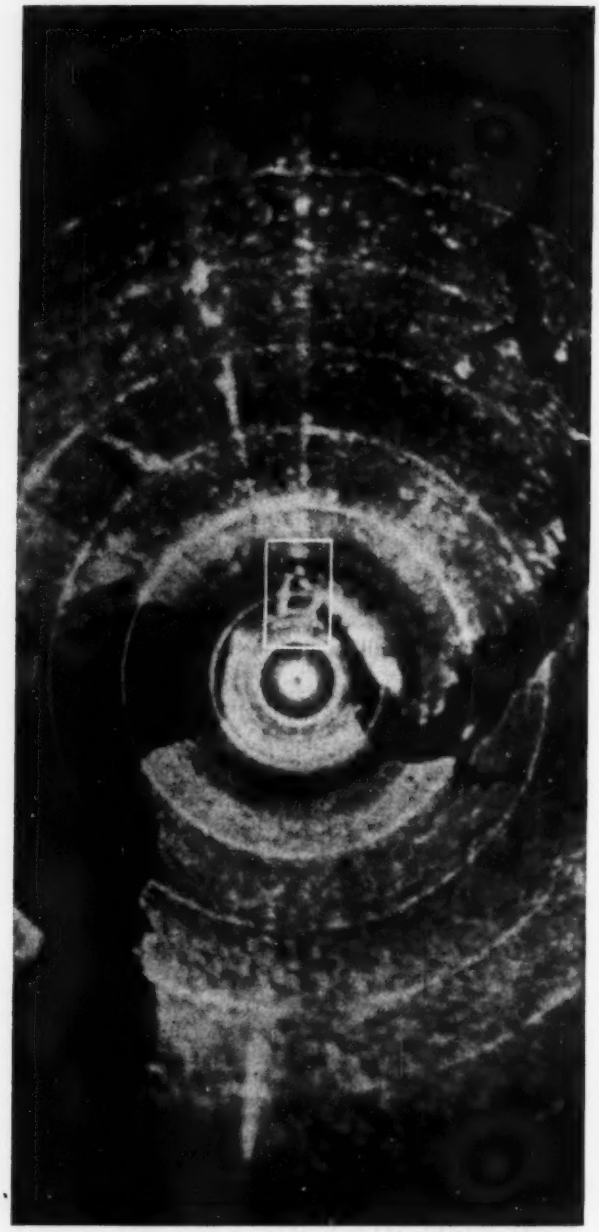
From personal experience as a pilot in World War I, Major Goddard was impressed with the need for night photographic cover, and during his first visit to our laboratories expressed his sincere conviction of the imperative need for night aerial photography. Then, as in World War II which was to come upon us in another two years, the enemy often moved at night, and again and again the High Command had need to know what went on at a particular place at night beyond enemy lines. The only satisfactory solution to such a problem is night aerial photography, the origin of which dates back more than a quarter of a century. A few photographic experiments were made in 1917 and 1918 with improvised flash bombs, but these tests were abandoned after a bad accident which practically demolished one of the buildings at Langley Field.

Two Systems of Night Photography

From World War I to 1939 progress in night photography was confined to refinements and improvements of flash-bomb techniques. Originally, the aerial camera shutter was opened when the bomb was dropped and was closed manually after the flash had occurred. An important advance was made in the middle of the 1930's when Goddard proposed that the camera shutter be tripped automatically by a photoelectric system actuated by the light of the bomb. Subsequent developments brought forth the Fairchild night camera with phototube control of the shutter, and the standard 50-pound flash bomb known as the M-46. So well did this photographic complement function that the English adopted the camera as standard equipment for their night reconnaissance work during the recent war.

In spite of apparent success, the flash-bomb method of night photography had several disadvantages. The flash bomb is dangerous because the powder is easily ignited. The number of reconnaissance operations is restricted since the number of bombs that can be carried is limited. The plane can operate only at a given altitude because the time-delay fuses, usually adjusted before take-off, are intended to be dropped from a predetermined altitude. Should there be a cloud layer between the plane and the target, the plane cannot complete its assignment by flying lower because of limitations imposed by the preset fuses.

The electric-flash system overcomes these difficulties since the equipment is not explosive, the number of photographs that can be taken is almost limitless, and the plane carries its own light source and consequently can operate at any altitude. These desirable features are not achieved without some disadvantages, however. Photographs made with the electric-flash system do not have shadows, which are helpful for identifying and indicating the heights of objects. As previously men-



Photograph of radar image showing a portion of Jacksonville, Fla. The plane is flying north and is close to the target — two bridges which can be seen as white lines in the center rectangle. Radar and radio direction-finding techniques were valuable adjuncts in guiding the plane to its proper destination for making night aerial photographs.

A strip of three electric-flash night photographs taken at Jacksonville, Fla. These three photographs, covering approximately the area marked as a white rectangle in the radar image, show clearly the objective sought — the two bridges across the St. Johns' River. These night photographs were made at an altitude of about 2,500 feet.

tioned, the weight of the flash equipment increases as the square of the altitude at which photographs are to be made, and this must necessarily establish an ultimate limit of usefulness of the electric-flash system. Finally, the considerable electric power requirement of electric-flash photography imposes a substantial load on the electrical system of the plane.

At first thought, the two systems of night photography might be regarded as competitive. It is more accurate to say that they complement each other. Under tactical conditions it was found that one or the other was better suited to photography for a given mission. A totally effective night squadron needs both systems and must be able to switch from one to the other at a moment's notice. The need for both systems was dramatically demonstrated during the invasion of Normandy on June 6, 1944.

On the night of D-Day there was a cloud layer at 3,000

The left-hand illustration is from an enlarged portion of a night photograph taken in Burma of an important crossing of the Irrawaddy River. A temporary footbridge (A) has been built just above the ferry slip, (B). A ferry boat, with Japanese truck in place, ready for crossing is on the lower river bank, (B). Two other trucks (C) and (D) await their turn to cross. The use of the ferry was unknown until this picture revealed the night activity on the river. During the day, the ferry boat was carefully concealed at some distance from the crossing. . . . At the right is a night photograph of an important crossroad intersection in Normandy taken on June 6, 1944. The photograph is significant for the absence of vehicular traffic at this important junction. Certainly German trucks would have been on this road had the Germans expected the Normandy invasion to take place. This, and similar photographs, gave early proof that the Germans were surprised completely by the invasion of Normandy.

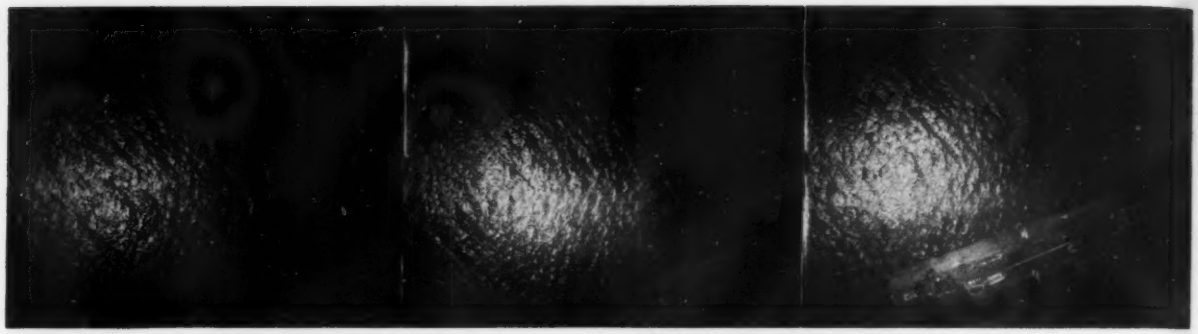
feet elevation over all the French area to be photographed, and therefore airplanes equipped with flash bombs were not able to accomplish their missions. A plane with an electric-flash unit was able to go below the clouds and photograph target objectives even though the area photographed was not as wide as that which would have been obtained by the flash-bomb method. Lieutenant Edward Lentcher, a pilot of the 155th Night Photo Squadron, found clouds as low as 800 feet. He banked his plane opposite the targets to get additional oblique coverage and returned with photographs which were of considerable tactical importance and which could not have been made by flash-bomb technique. One of these photographs is shown above, at the right.

Early Tests of Electric-Flash Equipment

The first experimental electric-flash unit for night aerial photography was given its initial trial in a B-18 Army Air Forces bomber in April, 1941, over Boston. This early equipment was normally operated at an altitude of about 2,000 feet, and with a camera covering a 40° cone, a region of land 1,500 feet in diameter could be photographed. With such photographs, buildings, roads, automobiles, and other objects could be easily distinguished and identified in night photographs.

The experimental equipment then was sent to Wright Field to undergo further exhaustive tests to demonstrate its practical utility. On the basis of this preliminary work, a larger and more comprehensive flash unit was designed to fit the B-24 and B-25 airplanes which represented the latest type of craft then available. As soon as the equipment was finished, it was flown to Dayton, and, in flight tests, exceeded expectations of its performance.

It was during these tests that the first opportunity was provided to recognize the rather unusual requirements of aerial night photography for military operations. Ordinarily, the military services depend on daylight aerial photographs to determine details of terrain of enemy territory, the location of enemy troops, guns, supply depots, and so on. Night aerial photography is employed primarily to provide intelligence of the enemy's operations under cover of darkness. Daylight photography is used to learn what force the enemy has; the role of night photography is to reveal how and where the enemy's force is being applied. For this purpose the primary target of night photography is motion; movement of troops and equipment along highways, railroads and waterways over as large an area as possible. So long as road traffic can be revealed in night photographs, excellence of photographic quality is very much less important than increased area of coverage. There is a tendency, therefore, to accept photographs which give the necessary intelligence, even though they may be of poor photographic quality if judged by more customary standards.



Photographing the Desired Objective

Once the early experimental equipment for the B-24 and B-25 planes was perfected, the Army requested models for use in maneuvers. The results of Army tests showed the photographic equipment to be satisfactory and capable of producing pictures well suited to military needs. For a while it seemed that the problem of aerial night photography had been solved. Soon, however, another problem arose; the photographs were seldom of the desired subjects. Night navigation, rather than night photography as such, had become the important problem.

Even in familiar territory where towns were lighted, night pilots had difficulty finding isolated crossroads and other assigned spots where there might be troop activity. Over enemy territory, with towns blacked out, the probability of photographing a particular road intersection appeared to be virtually zero. For this reason there was a lack of interest in further development by the Army who would be the primary user of the system for tactical reconnaissance.

It is now clear, of course, that several of the radar systems then being developed could have been extremely useful in solving the problem of night aerial navigation. Five years ago, however, even those who were frantically busy with the development of radar techniques and systems did not appreciate the full usefulness and capabilities of radar, and the secrecy which surrounded the subject at the time made it practically impossible for those not included in the "inner circle" to learn what was going on, or to take advantage of radar techniques.

Ultimately some of the developments of radio navigation and radar provided the means for precise night navigation which enabled night photographic reconnaissance to play its full part in tactical operations toward the close of the war. This was particularly true of the Gee system of radio navigation, developed in England between 1936 and 1939, in operation by 1941, and a standard method of navigation for British and American air forces from the autumn of 1943 until the end of the war in Europe.

Gee — an Aid to Navigation

The Gee system of radio navigation, to which Loran is similar, is fundamentally a method of radio location by which a plane in flight determines its position by measuring the time required for signals to reach it from two or more stations, separated by about 80 miles, whose radio transmissions are very precisely synchronized. If the signals from the two transmitting stations take exactly the same time to reach the plane, the plane is known to be equidistant from both stations. Its position is at right angles to, and along the bisector of, the straight line joining the two transmitters.

If the plane follows a course such that a constant time difference occurs between the synchronized signals reaching it from the two Gee transmitting stations, it can be shown that the plane will follow a hyperbolic course. Thus, two Gee (or Loran) transmitters are capable of producing a pattern of hyperbolas, each representing a different time difference in wave propagation between the stations. A plane may be guided along any hyperbolic pattern by requiring the navigator to follow a path of constant time difference, as indicated by the position of a mark on the screen of a cathode ray tube, or some similar indicator.

Three synchronized stations, properly located, establish a grid network or system of orthogonal hyperbolas enabling the navigator to determine his position accurately with respect to the Gee stations whose locations are known. The precision with which the navigator can locate his plane varies somewhat with his position relative to the transmitting stations, but the error is usually not appreciably greater than half a mile in either direction.

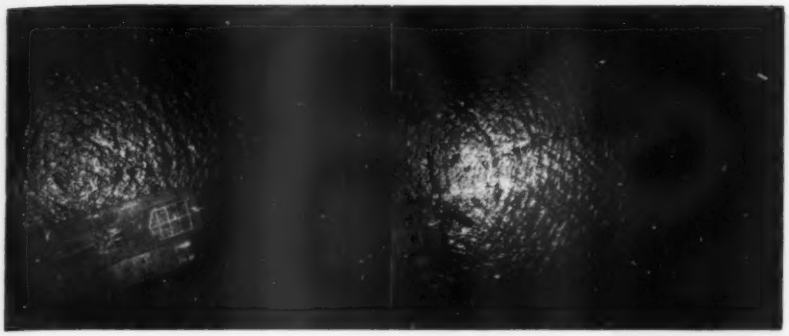
By the time American planes were operating in large numbers in England (in late 1943 and early 1944) the Gee system was in full operation. Gee was an important aid in landing planes in England, and covered the English Channel, the North Sea, Holland, Belgium, Northern France, and other regions in the interior of the Continent. Using ground stations on the English Coast, Gee was an effective aid in bombing the Ruhr. A range of about 200 to 250 miles was obtained for aircraft at 15,000 feet. For low altitude, night reconnaissance work, the range was nearer 100 miles. Providing a means for a plane to locate its position to within half a mile over the entire European region of greatest tactical importance, Gee was just what was required to make full use of night photographic reconnaissance.

But we are ahead of our story.

From Cassino to the Po Valley

Before night aerial photography was effectively teamed up with radio and radar aids to navigation, calls for night photographic equipment frequently came from the front. One of these was especially memorable for the effect it had on the future course of the war and because it was used in an area where the topography was an important and effective aid to aerial navigation at night.

In April, 1944, when our army was stalled below Cassino in Italy, there was a need for night reconnaissance to discover how the Germans were receiving supplies even



A series of five test photographs taken at the rate of three pictures per second at an altitude of 200 feet with flash equipment weighing 150 pounds. The object of such photographs is to show what was attacked by the plane and how close the bomb came to hitting the target. No bombs were dropped in this practice run. Night bomb runs at low altitudes on submarines that surfaced to charge their batteries were very successful at one stage of the war.

though all bridges which might have been effective in military transportation had been destroyed. Lieutenant General Ira Eaker requested some electric-flash equipment for night photography. Colonel H. K. Baisley, then Chief of the Photographic Laboratory at Wright Field, responded by sending a B-24 and two B-25 airplanes equipped with cameras and electric-flash lamps. The author was requested to accompany the mission, to train men to install and maintain equipment, and to assist in applying night photography to the military operations being planned. Corporal Donald Castle, who had spent several months at M.I.T. learning the theory of electric-flash equipment before he went overseas, was assigned to the same mission.

We left from Wright Field in the B-24 and went directly to San Severo, Italy, via the southern route through South America and Africa, which was the route used by the 90th Photo Reconnaissance Wing. In Italy, the B-24 was found to be too slow and too large a plane for effective photographic reconnaissance; it provided too good a target for enemy guns. The photographic equipment from the B-24 was therefore transferred to two faster and more maneuverable A-20 airplanes. After the two A-20's were equipped, enough additional apparatus was still on hand to form the nucleus of a photographic unit which was later formed in England.

Some time was spent in getting the A-20's in readiness and in working out the problem of supplies. Aerial reconnaissance was hampered by lack of planes and replacement parts. Early test flights appeared to show that Italy was entirely covered with olive groves, even including regions which were definitely known to be in the Mediterranean Sea! The difficulty was quickly traced to outdated and poorly stored film, some of which actually had water condensed on the emulsion when the boxes were opened. Most of the film for night aerial photography had come via Africa where it had not been properly stored. We never had film for night photography that was less than a year old.

Nevertheless, after three months' work it was a great satisfaction to learn that the results of two test flights were regarded so highly that similar equipment was requested in England. Captain Calvin Wheeler was the pilot of the first flight mission out of San Severo and Corporal Castle was the photographer, but many more missions followed this initial trip. In all, some 50 night missions were made for photographic purposes while our Army was advancing from Cassino to the Po Valley.

Under favorable conditions, satisfactory night photographs had been made from an altitude of more than 10,000 feet.

The results of night photography in the Italian campaign were sufficiently successful that in May, 1944, a request came from England to assist in outfitting a night photo squadron. The equipment which was not needed in Italy was flown via Africa to Chalgrove, England, where the 155th Night Photo Squadron was being created from a group of former night fighter pilots. Immediately we could sense that something important was in the making. Three days after landing, the first A-20 was equipped with electric-flash equipment and the group of seasoned pilots and photographers were given instructions in the proper use of the photographic equipment.

Most important of all, however, was the prospect of developing night photography to its peak. For the first time we could look forward to the co-operation of effective night photography and precision navigation. Our own Army navigators were being trained to operate the English Gee radio navigation devices, and they quickly learned to appreciate the value of knowing their precise location. During the last part of May, 1944, many training flights were made over England to prepare the crews for the work that we all knew could not be far in the future.

Surprise!

On the evening of June 5, 1944, a tense, earnest atmosphere pervaded as those in charge of the squadron checked over the crew and equipment. We had no advance information, but we did not need it. We knew that practice reconnaissance over England was ended and that the time had come when night photographs of the combat area would be demanded.

Shortly after the take-off of the night photographic airplanes for Normandy, there began the long caravans of C-47 planes with trailing gliders full of invasion troops. These seemingly unending streams of planes passed directly over the Chalgrove Airport at an altitude of 1,000 feet and presented an inspiring sight never to be forgotten by those who witnessed it.

Before the last plane of invasion troops left England, some of the night photo airplanes had returned to England with their valuable cargo of exposed film. The films were rushed through the photographic laboratory for processing but they showed no action on the important crossroads leading into the invasion area. The pilots, anxious to obtain action pictures, were somewhat disappointed at the results, but the High Command was extremely pleased. It knew then, as we all know today, that the Germans had been taken completely by surprise and that, as a result, our invasion operations would be more successful and with fewer casualties than

Rear view of an A-20 airplane showing an electric-flash reflector mounted in the tail

if a formal "reception" awaited our troops in Normandy.

It is difficult to assess precisely the contribution made by night aerial photography to the success of the Normandy invasion, for military intelligence is assembled from many sources. The final decisions and commands are ultimately made known, but the information upon which they are based and the importance of each bit of intelligence cannot readily be evaluated. But it can hardly be doubted that early knowledge that the Germans were taken by surprise — knowledge first furnished by aerial photography — must have had an important bearing on invasion operations, especially immediately after the first landings. But at least one important result did come out of these operations; during the Normandy invasion, the 155th Photo Squadron firmly established the value of radar and radio navigation as an element of night photographic reconnaissance.

In August, 1944, after our troops had an incontestable hold on France, the 155th Photo Squadron moved to Rennes, France, to be nearer military operations as the Allied Armies crossed Europe. The Squadron made four other moves as it followed the action of the Allied Armies across Europe. That the work of this group was of great value is, perhaps, best attested by the commendations from the High Command which this squadron received.

Record of the Battle of the Bulge

One of the outstanding efforts of the Squadron was the photographic work performed over the Ardennes Forest during the Battle of the Bulge in December, 1944. At best, during this time of the year, there are only three or four hours of the day when good aerial photographic reconnaissance can be accomplished by daylight. In the winter clouds shroud the rugged, hilly land of the Ardennes Forest which is 500 to 1,000 feet high. For these reasons it was impossible to make reconnaissance flights during daylight. At night, clouds dissipated and cleared up, so night photography was possible. In fact, night aerial photography was the only possible means of reconnaissance from the time the Battle of the Bulge started, on the night of December 16–17, until December 23, and accordingly there was a very active and concentrated program of night photography, using electric-flash equipment and flash bombs.

Two routes of troop movement and of supply were available to the Germans leading to the spearhead of the Bulge. One of these passed through the pocket controlled by the isolated division at Bastogne and could not be used by the enemy. The other route passed through St. Vith in Belgium. In fact, St. Vith was the center of routes of supply and troop movements as revealed by night photographs. The German effort could be made substantially less effective, therefore, by reducing the transportational value of St. Vith, which was, accordingly, heavily bombed. It is interesting to record that bombing operations on St. Vith were carried out completely on the basis of information obtained from night aerial reconnaissance.

Evaluating Aerial Night Photography

In attempting to assess the value of night photography the question is often asked whether any outstanding new developments in electric-flash photography were made during the war. This question can best be answered by stating that although no radically new systems of operation were devised, there were many improvements of capacitors, flashtubes, and other components. In the aggregate, these improvements resulted in a considerable advance in the performance beyond that which was possible when the program was originated in 1939. As an example of such progress, it may be recalled that experimental units delivered to Wright Field in 1941 were limited to use at altitudes no greater than about 2,000 feet. When the war ended, equivalent photographic performance was obtained at 10,000 feet and, under favorable conditions, usable photographs have been made at 20,000 feet. Certainly a very great advance was made in the effectiveness of night photography when aerial photography was combined with precision methods of navigation.

Night aerial photography using electric-flash equipment was used on nearly all fronts during World War II in a variety of airplanes and for a variety of purposes. Particularly when supplemented by radio and radar navigational aids, night photography demonstrated its usefulness magnificently in Italy and Normandy. From the record of military accomplishments it is now clear that night photography has become an established although difficult art, virtually indispensable in tactical warfare. The peacetime training of our photo reconnaissance pilots will undoubtedly include some activity in the field of night photography. The electric-flash system is preferred for training purposes since the dangers incidental to bombs are avoided. Furthermore, electric-flash photographs can be taken anywhere, whereas with flashlight bomb techniques exposures cannot be made over inhabited areas. (*Continued on page 310*)

A Century of Sleep

When Reviewed in the Light of 10 Decades of Painless Surgery the Faltering Developments and Early Uses of Anesthesia Assume New and Brighter Luster

By Tenney L. Davis

THE luster of great events, like that of great men, shines brightest at a moderate distance. In their own times and places important events seem trivial, but they later develop far-reaching consequences and implications. Their effects furnish proof of greatness, and in general, endure long after the mere luster has faded.

Almost exactly a century ago, in February, 1847, Sobrero reported the discovery of nitroglycerin to the Academies of Torino and Paris. He observed the sweet taste of his fulminating glycerin and its power of producing violent headaches. He demonstrated its explosibility, but was not able to control it. Sixteen years elapsed before it was manufactured and used commercially — by Alfred B. Nobel in Sweden in 1863. Soon thereafter, in 1867, Nobel invented dynamite, the liquid and dangerous nitroglycerin absorbed by fuller's earth by which it was rendered more safe and more tractable. In the same year he devised the fulminate blasting cap by which dynamite could be exploded at will, a device upon which the whole science and art of modern high explosives depends. Two years more, in 1869, improved "straight" dynamite came into being. In 1875, Nobel invented blasting gelatin and gelatin dynamite in which the nitroglycerin is converted into an elastic jelly by the addition of nitrocellulose. Another 13 years elapsed before he used a larger proportion of nitrocellulose to convert nitroglycerin into a stiff, hornlike colloid for use as smokeless powder. Nobel invented Ballistite in 1888, more than 40 years after the discovery of nitroglycerin.

First Evaluations

The history of Nobel's inventions is a story of ingenuity, persistence, and resourcefulness. In the end Nobel was rewarded by great wealth which permitted him to endow the Nobel prizes for advancements in peace, science, and the humanities. If only the first and immediate consequences of Nobel's inventions are considered, the account becomes a history of the explosives industry, of mining, and of military tactics. Nobel started something which made it possible to build the Panama Canal, to take coal out of the earth, to find petroleum and bring it to the surface, to wage war with the newest of weapons, to procure tungsten from which filaments are made for the searchlights of battleships and for the lamps of libraries.

Like Nobel, Sobrero also started something. If one sets out to discuss the consequences which have followed from the simple experiments of Sobrero in 1847, to discuss the relationships and results of the consequences themselves, he will find that he has undertaken a discourse on the social, economic, and cultural life, and the industrial and engineering achievements of a century.

Some other great event, followed through the ramifications of its consequences, will yield another history of the same period, differently focused, differently colored, no less authentic, and perhaps more interesting.

A century ago last autumn, an epoch-making event occurred in Boston, in the Massachusetts General Hospital, in the operating room under the Bulfinch dome. It is described simply and forthrightly on a plaque which is attached to the wall of the room, in language composed by President Eliot of Harvard and Dr. Henry P. Walcott, Chairman of the Trustees of the Hospital:

> On October 16, 1846, in this room, then the operating theatre of the hospital, was given the first public demonstration of anaesthesia to the extent of producing insensibility to pain during a serious surgical operation. Sulphuric ether was administered by William Thomas Green Morton, a Boston dentist. The patient was Gilbert Abbott. The operation was the removal of a tumor under the jaw. The surgeon was John Collins Warren. The patient declared that he had felt no pain during the operation and was discharged well December 9. Knowledge of this discovery spread from this room throughout the civilized world and a new era for surgery began.

The celebration of the centenary of surgical anesthesia occasioned several important publications, important as documentation and history, informative to read, and interesting because they illustrate the diversity of the consequences and relationships which adhere to great events. Notable speeches, worthy of discussion, were made at the ceremonies in Cambridge, but we limit our present review to four printed publications: one from Harvard, two from Yale, and one, a history of anesthesis, providing a cross-section of the history of medicine.

Adventure in Co-operation

Three months before the date of the actual centenary, an article was published in the *Harvard Alumni Bulletin* of July 6, 1946, entitled "The Story of a Hospital. The MGH and the Medical School: an Adventure in Co-operation" by Joseph Garland. The author pointed out that the early history of medicine in Massachusetts is intimately related to the development of the Harvard Medical Faculty and the founding of the Massachusetts General Hospital. "Massachusetts medicine," including ether anesthesia and other contributions to the medicine of the world, "grew through the influence of what Dr. Harvey Cushing called the medical dynasties of the community and hospital." John Warren, one of the founders of the Massachusetts Medical Society, was the first professor of anatomy and surgery at the Harvard

Medical School. He was also a brother of Dr. Joseph Warren, known to every school boy as the hero of Bunker Hill, and father of John Collins Warren who performed the famous first painless surgical operation under ether anesthesia. A Warren of the third generation, Jonathan Mason Warren, assisted his father in that operation, and served on the staff of the Massachusetts General Hospital. Jonathan's son, John Collins Warren, II, was professor of surgery at Harvard, and grandson, John Warren, who died in 1928, — the fifth Warren in line — was associate professor of anatomy at Harvard.

The Garland article discusses the Jackson and Bigelow dynasties, and mentions the Shattucks, the Cabots, the Richardsons, the Mixters, and others. It is filled with references to persons, places, and events which will awake latent associations in the memories of any who grew up in the neighborhood of Boston. It paints a picture of the old horse-drawn ambulance, black with its white horse and polished brass, describes the old Medical School Building on North Grove Street, gives a vivid account of the McLean insane asylum on the Barrell estate in Somerville, on a site now occupied by railroad tracks. Fifty years ago, the asylum was nothing but ruins, broken walls, cellars, tunnels, and underground passages where the boys of Somerville and Cambridge used to play pirates and runaway slaves. Thus, the great event leads deep and far. The article is a first-rate contribution to the history of medicine, and to the cultural history of Massachusetts. It deserves to be preserved where it will be available for the use of future historians.

Intended primarily for the use of future scholars, and obviously destined to be preserved in libraries, are two beautifully printed, book-size, paper-bound publications, Nos. 14 and 15, of the Historical Library of the Yale Medical Library. Both were published on the exact day of the centenary, and issued in consequence of the efforts of the learned, energetic bibliophile and bibliographer, John F. Fulton, Sterling Professor of Physiology at Yale. They are *A Memoir to the Academy of Sciences at Paris on a New Use of Sulfuric Ether* by W. T. G. Morton of Boston in the U.S.A., Presented by M. Arago in the Autumn of 1847, with a Foreword by John F. Fulton* and *The Centennial of Surgical Anesthesia, an Annotated Catalogue of Books and Pamphlets Bearing on the Early History of Surgical Anesthesia.* Exhibited at the Yale Medical Library, October, 1946. Compiled by John F. Fulton, M.D. and Madeline E. Stanton, A.B.†

Unprofitable Discovery

Morton was 27 years old when he made his first public demonstration of ether anesthesia. He had just passed 28 when he completed the *Memoir* addressed to the French Academy, in which he makes a calm and dignified statement of his claims to the discovery, as against those of his onetime partner, Dr. Horace Wells, and of his teacher in dentistry, Dr. Charles T. Jackson. He wrote it after he had learned that Dr. Jackson had twice sent surreptitiously to the Academy at Paris memoranda claiming full credit for the discovery of surgical anesthesia. At the time, Jackson was probably not wholly sound mentally. He wished for prestige and honor, but he also wished for money and a share of the nonexistent profits from the patent which Morton had taken out. Morton's *Memoir* closes with the following paragraph:

> In justice to myself, I should say, that I took out my patent early, before I realized how extensively useful the discovery would be, and beside the motive of profit and remuneration to myself, I was advised that it would be well to restrain so powerful an agent, which might be employed for the most nefarious purposes. I gave free rights to all charitable institutions, and offered to sell the rights to surgeons and physicians for a very small price, such as no one could object to paying, and reasonably to dentists. I had little doubt that the proper authorities would take it out of private hands, if the public good required it, making the discoverer who had risked reputation, and sacrificed time and money, such a compensation as justice required. But as the use has now become general and almost necessary, I have long since abandoned the sale of rights, and the public use the ether freely, and I believe I am the only person in the world to whom this discovery has, so far, been a pecuniary loss.

History of Anesthesia

Morton employed a paid publicity agent, a certain Edward Warren of Palmyra, Maine (not related to Dr. Edward Warren, brother of John Collins Warren) to write and publish a tract in his defense, "Some Account of the Letheon; or, Who was the Discoverer?" Five printings in three editions were published in Boston month by month from March through July, 1847. They contain numerous letters, editorials, and testimonials, now precious documents for the historian, among them in the second issue of the second edition the celebrated letter to Morton from Oliver Wendell Holmes. But the controversy continued. Congressional hearings dragged on for 20 years. The outcome is summarized briefly in a paragraph of the introduction of the *Annotated Catalogue:*

> The controversy was still unsettled when Morton had a cerebral hemorrhage on 15 July 1868, shortly after he had read J. H. Abbot's paper in support of Jackson in the *Atlantic Monthly* for June 1868. Jackson in turn had an acute maniacal attack when in 1873 he stumbled upon Morton's epitaph in Mount Auburn Cemetery: "William T. G. Morton, Inventor and Revealer of Anesthetic Inhalation. By whom pain in surgery was averted and annulled. Before whom in all time surgery was agony. Since whom science has control of pain." Thereafter Jackson, who had completely lost his reason, was confined in the McLean Hospital where he eventually died in 1880.

What a movie could be made from such events!

In January, 1842, Crawford W. Long of Jefferson, Georgia, entertained a party of friends with an ether frolic, a hilarious evening in which a number of cuts and bruises were administered without being felt. Long concluded that ether abolished pain, and about two months later, on March 30, put the matter to the test. After administering ether, he removed a small cystic tumor from the back of the neck of a patient who later testified that he had felt no pain, and who, indeed, submitted to the painless removal of a second tumor on June 6, 1842. Before September, 1846, Long had performed eight surgical operations with ether anesthesia, but he published no accounts of them until December, 1849, when, having heard of the controversy over Morton's claims, he contributed a short paper to the *Southern Medical and Surgical Journal.* (*Continued on page 308*)

* New York: Henry Schuman, 1946. 24 pages. $1.50.
† New York: Henry Schuman, 1946. 102 pages. $4.00.

Too Few, Too Late

Developed Too Late in the War To Be Useful to the Enemy, a Group of German Remotely Controlled Rockets Might Have Become Formidable Weapons Against the Allies

By Willy Ley

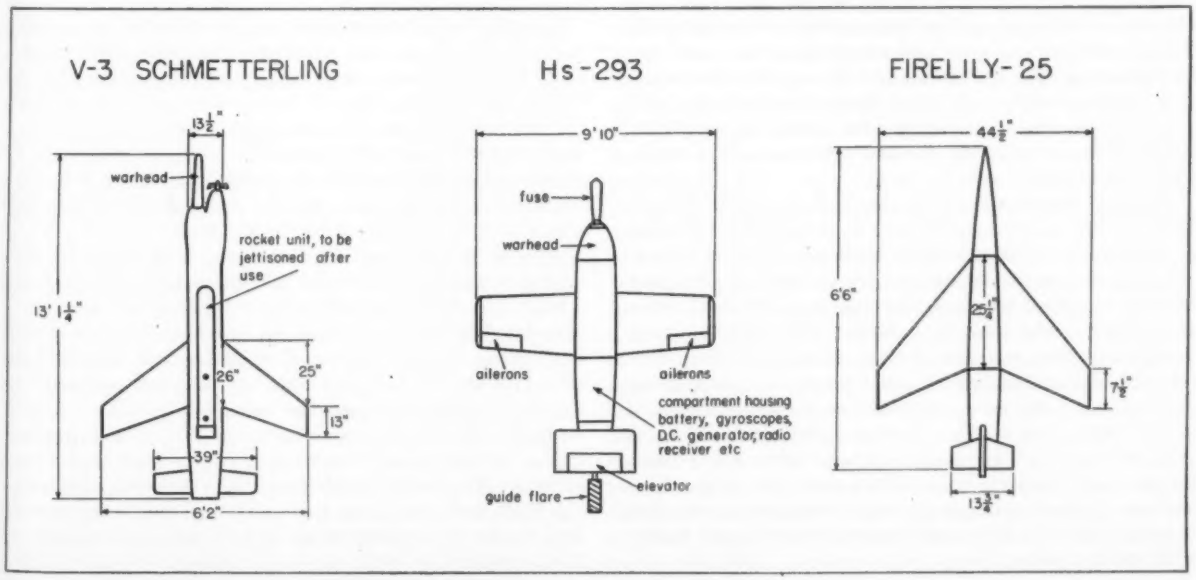
ONE year before the Russian and American Armies met inside Germany, one of the research chiefs of Junkers Flugzeug und Motoren Werke, (identified only as Professor Wagner) informed a selected group of German army officers and Nazi party officials that the problem of Allied bombing raids had been solved. He said that prior to 1944 the Royal Air Force Bomber Command and the American bombing fleets operating from British bases might have impeded war production and transportation but such operations no longer became possible with the development of a new kind of antiaircraft rocket, ground launched and guided by means of radio with the aid of sighting and acoustic devices. Each launching of one of these weapons was to be so accurate that it would account for a British or American bomber. What could be more simple or more satisfactory?

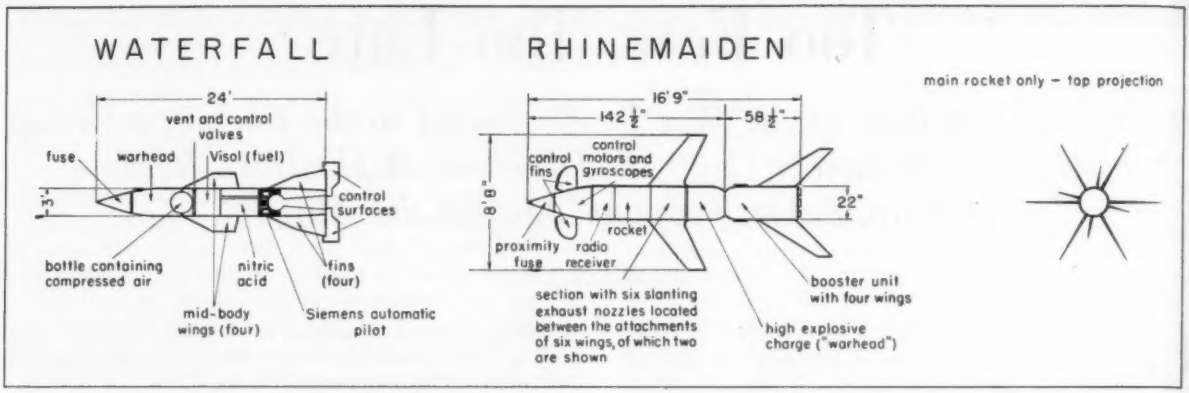
Of course the new weapon could not prevent the English and the Americans from building bombers. It could not even prevent them from sending these bombers against targets in Germany. But once the bombers got near their targets only one Junkers antiaircraft rocket would be needed to dispose of each Allied bomber. The Germans had reduced an important military problem to a mere matter of production — and there could be no doubt that Germany would produce more rockets than Great Britain and the United States could produce bombers and train crews for them.

The weapon about which such hopeful remarks were made was called the *Schmetterling* (*Butterfly*) by the engineers, and in anticipation of the time when the new weapon would go into action, the Ministry of Propaganda had reserved the designation V-3 for it.

One year later the *Schmetterling* was still not in action, but it was ready for mass production and the Allied Armies captured a number of test models and even a few production models. In appearance, the V-3 was a small airplane, thirteen feet, one and a quarter inches long, with a wing span of six feet, two inches. The fuselage, thirteen and a half inches in diameter, had a forked nose. A long conical warhead was attached to the port side of the odd nose and, at starboard, a six and a half inch four-bladed impeller activated the electrical devices. The fuselage was given over to the various control devices and the fuel tanks, but it did not carry a rocket motor. The fuel was burned in two rocket units, which operated either together or separately. They were attached on top and below the fuselage and were jettisoned when expended. The extreme tail end of the fuselage carried a guide flare.

The *Schmetterling* was extremely fast, being capable of attaining a maximum speed of 620 miles per hour with a range of approximately 30 kilometers (20 miles) and having a ceiling of 50,000 feet. One of the interesting features of the mass production model was the wing which was cast in one piece of light metal alloy. It consisted of six main ribs, main spar and trailing edge, with a tubular attachment spar. This structure was then covered with thin aluminum alloy sheet.





It appears that about the spring of 1943 — two years before V-E Day — all German aircraft manufacturers and some armament manufacturers received instructions to concentrate on the development of antiaircraft rockets, guided missiles which were either ground launched or carried aloft by defending aircraft. Consequently, the V-3, or *Schmetterling*, was only one of a great number of such developments.

The Henschel, Hs 293, antishipping rocket bomb, had been the first of these missiles. It was used for a short time against Allied convoys and, although not too accurate, it did disable or destroy several Allied merchantmen. A later development, unfinished at the time the Henschel factories fell into Allied hands, was the Hs 298. It was smaller than the 10-foot Hs 293, having a wing span of only four feet, two and three-quarters inches and a length of six feet, seven inches. Its launching weight, 210 pounds, was 140 pounds less than that of the *Schmetterling*. The nose arrangement of the Hs 298 was essentially the same as that of the *Schmetterling*, except that the warhead was located above the impeller.

While the *Schmetterling* was a ground launched, antiaircraft weapon, the Hs 298 was launched from an airplane. Its anticipated use was against Allied bombers, but presumably it could also have been used against surface vessels or ground targets. The old Hs 293 had meanwhile been replaced by the Blohm und Voss, Bv 246, an antishipping glider bomb, with a wingspread of twenty-one feet, one inch, and a fuselage eleven feet long. In appearance the Bv 246 looked like a half-scale model of a personal glider. Its total weight was about 1,600 pounds, the warhead accounting for 1,000 pounds of that weight. The wings of the Bv 246 were made of concrete with a metal mesh core.

All these weapons must be classified as aerial counterparts of the naval torpedo and it is highly interesting to see how some of the ideas first employed in experimental naval torpedoes, as far back as 70 years ago, have recently cropped up again in the designs of German aerial bombs and rockets. A large number of the early naval torpedoes, intended for use mainly by shore batteries, had been equipped with electric lamps sticking out on four-foot poles, so that the torpedoman could guide them better. The Germans equipped all their ground-to-air and air-to-air weapons with guide flares for the same purpose. Some of the early naval torpedoes had been guided by trailing wires; it is somewhat amazing to relate that the Germans also had an air-to-air rocket with trailing wires.

The trailing-wire weapon was the X-4, a liquid fuel rocket propelled by hydrazine hydrate and alcohol and intended to be released from defending planes against bombers. The rocket was six feet, eight inches long. It had four tail fins and, in addition, four short wings near the center of the body. From tip to tip these short wings spanned one foot and seven inches. The diameter of the rocket itself was eight and a half inches, and the warhead carried by the rocket weighed 50 kilograms (110 pounds). When released from the bomb bay of the defending plane, the X-4 forged ahead under its own power with more than twice the speed of the airplane. By means of two guide flares attached to one set of opposing wings, the pilot in the defending plane could watch the rocket and could guide its path by radio control. The other set of two opposing wings carried 24-inch streamlined bobbins, each holding six kilometers (about four miles) of fine, insulated copper wire through which electrical impulses were sent to the rocket's control mechanism.

Another one of the winged aerial torpedoes which the Germans devised too late for use in World War II was the *Feuerlilie 25* (*Firelily*) which had been developed by the Hermann Göring Research Institute. The *Firelily*, propelled by a powder rocket with a burning time of six seconds, was not meant as a weapon by itself, but served merely as a research instrument with which to gather data for the design of such weapons.

In addition to these various kinds of flying torpedoes, the Germans were also working on rockets for antiaircraft fire which were only slightly modified examples of "straight" rockets. One of them, of which a number of slightly different models were captured in various places, was named *Wasserfall* (*Waterfall*). Externally, it bore a strong resemblance to the long-distance rocket A-4, the main difference being a set of four wide-chord stubby wings near the middle of the rocket body.

The *Waterfall* stood 24 feet high, with a maximum diameter of three feet, and a take-off weight of three and a half tons. It was propelled by a fuel called Visol (presumably Visol A, code name for vinyl ether) with nitric acid as an oxygen carrier. The rocket was subdivided into a number of compartments. A radio fuse, detonated from the ground, formed the nose, followed by a large warhead. The end compartment of the rocket proper held a spherical bottle containing compressed air for the controls. Next to the bottle came the valve compartment, the Visol tank, the nitric acid tank, and finally the power bay, containing two servo motors (in one case a Siemens K-12 automatic pilot unit) (*Continued on page 304*)

THE INSTITUTE GAZETTE

PREPARED IN COLLABORATION WITH THE TECHNOLOGY NEWS SERVICE

Family Tradition

THIS month The Review reinstates a custom, unavoidably broken during the war, of listing the names of those who carry on family tradition and "Come Back to Tech" to prepare for careers in science, engineering, and architecture. As shown in the tabulation below, this year 21 sons follow in the footsteps of their fathers in enrolling at the Institute:

Son	*Father*
Clifford S. Abrahamson	Clifford O. Abrahamson, '25
Frederick W. Adams, Jr.	Frederick W. Adams, '21
Philip M. Alden, Jr.	Philip M. Alden, '22
Stephen R. Arnold	Robert M. Arnold, '22
David W. Chaffin	Warren L. Chaffin, '20
Clarence M. Cornish, Jr.	Clarence M. Cornish, '24
Herbert C. DeStaebler, Jr.	Herbert C. DeStaebler, '21
Richard T. Hall	Charles L. Hall, '15
Van Court M. Hare	Van Court M. Hare, Jr., '23
George L. Hildebrand	Lee E. Hildebrand, '27
Richard S. Holmgren, Jr.	Richard S. Holmgren, '19
Paul A. Lobo	Walter E. Lobo, '26
Robert C. Loesch	Willard G. Loesch, '21
John H. MacMillan	Henry J. MacMillan, '24
James R. Maxwell, 3d.	James R. Maxwell, Jr., '22
Frederick D. Newell	Joseph S. Newell, '19
William C. Reed	Charles S. Reed, '16
Richard P. Sabin	Palmer Sabin, '15
Stephen H. Senzer	Sidney Senzer, '21
Herbert P. Sontag	Herbert P. Sontag, '25
Sherwood B. Stockwell	Ernest F. Stockwell, '22

Radiochemical Industry

PRESENT at the 254th meeting of the Alumni Council, held on January 27, in Pritchett Hall of Walker Memorial, were 124 members and guests. In calling the meeting to order after dinner, President Bugbee reported that the January meeting was the last one to be held in Pritchett Hall which would be converted into a refreshment lounge. Alumni guests introduced by President Bugbee were Arturo Marqués, '27, Secretary of the M.I.T. Club of Uruguay, William H. Mueser, '22, chairman of the Twenty-Five Year Class Committee, and Gordon G. Holbrook, '10, member of the National Nominating Committee.

H. E. Lobdell, '17, was called upon to introduce his successor, Dr. Everett M. Baker, Dean of Students. In response to a genial welcome, Dean Baker expressed pleasure in assuming the duties of dean of students at the Institute and looked forward with eagerness to the opportunities his new post afforded.

As recorded on the following page, under the heading "Democracy in Action," the list of nominees for officers and representatives of the Alumni Association was presented and affirmatively voted. Also elected were members of the committees having responsibility for Alumni Day, June 14, as recorded on pages 284–285.

Reporting for the Administration, President Compton enumerated four recent developments affecting the Institute's management. Recently introduced in the State Legislature was a bill designed to limit to 35 per cent of the total enrollment the number of students normally residing outside of Massachusetts. The opposition from Massachusetts colleges and universities to this bill was so strong that the bill was reported unfavorably in the Legislature. Because of expenses of reconversion, the Institute's operating deficit is expected to be $370,000 for the year. A program of student counseling is being put into operation, the objective of which is to obtain a better distribution of students among the various courses or departments. At present a few departments, such as those of Electrical Engineering, Physics, and Aeronautical Engineering face the prospect of having more students than can be adequately accommodated, whereas facilities exist for more students in such courses as Biology, Marine Engineering, Meteorology, Geology, and Economics. Dr. Compton also reported that Mrs. William H. Kales, wife of the late William H. Kales, '92, a former member of the Corporation, had agreed to underwrite the cost for expanding the facilities of the Kales Clinic to serve as a first-class eye, ear, nose, and throat clinic. The Kales Eye Clinic was dedicated on Alumni Day, June 8, 1946, as reported in the July, 1946, issue of The Review, and will soon be expanded as indicated above.

President Bugbee then introduced Dr. Charles D. Coryell, Professor of Chemistry at M.I.T. who, during the war, had charge of fission products at Oak Ridge, Tenn. Dr. Coryell gave an illustrated talk on "The Radiochemical Industry" in which it was shown that the successful operation of the chain-reacting pile on December 2, 1942, had created a whole new field in large scale operations with radioactive materials. Spectacular results have already been attained in this field to which much more attention must still be given, however. The fission products encompass several hundred radioactive isotopes; in addition, nearly all of the remaining elements of the periodic system can be made radioactive by exposure to the neutron field of the pile. Recently the government has made many of the active materials available to American research organizations at comparatively low prices.

An important part of the talk consisted of the presentation of slides showing the installations and apparatus for the preparation, separation, and distribution of radioactive materials. The handling of radioactive materials introduced many new problems not previously encountered in industrial operations. These include removal of the materials from the pile, transfer of materials to the laboratories, dissolving and processing operations with remote control for all operations, using methods of precipitation, solvent extraction and adsorption, subdividing, and packaging. At all times precautions were required to protect personnel from excess radioactivity and to eliminate radioactive contamination.

It is expected that further expansion will occur in the applicability of radioactive materials. There is great need for new apparatus, new techniques, and new procedures. These opportunities and needs should be a challenge to our technical abilities.

Democracy in Action

INTO the mails this month will go ballots for the annual election of officers and representatives of the 40,000 Alumni of the Massachusetts Institute of Technology. Nominee for the presidency of the Association, to be elected this spring, is Raymond Hall Blanchard, '17, X, Vice-president in charge of manufacturing and Director of the Hood Rubber Company, Watertown, Mass., a division of the B. F. Goodrich Company.

The Association's National Nominating Committee — consisting of Robert S. Williams, '02, chairman, Albert W. Higgins, '01, Ralph C. Robinson, '01, Fred W. Morrill, '07, Harry L. Havens, '09, Gordon G. Holbrook, '10, Irving W. Wilson, '11, Robert C. Erb, '17, Charles A. Williams, '21, and Charles H. Toll, Jr., '23 — nominated for election to the vice-presidency of the Association for two years John A. Lunn, '17, II, Dewey and Almy Chemical Company, Cambridge, Mass. Nominees for the election to posts on the Executive Committee for two years are: Horatio L. Bond, '23, XV, National Fire Protection Association, Boston, and Dwight C. Arnold, '27, XV, Stevens-Arnold Company, Inc., South Boston.

Named for alumni term membership on the Corporation of the Institute for five-year terms are: Harold Bugbee, '20, X, XV, President, Walter B. Snow and Staff, Inc., Boston, and retiring President of the Alumni Association; James McGowan, Jr., '08, V, President, Campbell Soup Company, Camden, N. J.; and C. George Dandrow, '22, IX-B, Vice-president and General Sales Manager, Industrial Products Division, Johns-Manville Sales Corporation, New York City.

To succeed Messrs. Higgins, Havens, and Toll, new representatives on the National Nominating Committee to be elected this year (one from each district) are: *District 8:* Oscar G. Thurlow, '04, I, The Commonwealth and Southern Corporation, Birmingham, Ala.; Jonathan A. Noyes, '12, II, Sullivan Machinery Company, Dallas, Texas; Van Court M. Hare, Jr., '23, IV, Tennessee Valley Authority, Knoxville, Tenn.; *District 9:* Carl J. Trauerman, '07, III, Mining Association of Montana, Butte, Mont.; Alfred E. Perlman, '23, XV, Denver and Rio Grande Western Railroad Company, Denver, Colo.; Stephen L. Macdonald, '39, IV, architect, Salt Lake City, Utah; *District 10:* James O. Greenan, '11, III, Greenan and Company, Inc., Reno, Nev.; Henry C. Gunning, '26, XII, University of British Columbia, Vancouver, B. C.; Charles S. Camplan, '31, XVII, United States Inspection Division, Portland, Ore.

Nominees for Class Representatives on the Council: George M. Tompson, '73, John C. Runkle, '88, Frederic H. Keyes, '93, Edward S. Chapin, '98, James A. Cushman, '03, Joseph W. Wattles, 3d, '08, R. Charles Thompson, '13, F. Alexander Magoun, '18, George A. Johnson, '23, Arthur A. Nichols, '28, Robert M. Kimball, '33, Albert O. Wilson, Jr., '38, and Frederick G. Perry, Jr., '43.

FOR PRESIDENT

. . . of the Alumni Association, Raymond H. Blanchard, '17, X, has been nominated for election for the coming year. Mr. Blanchard has served his company since 1917, in 1932 advancing to his present position of vice-president in charge of manufacturing, and director of the Hood Rubber Company, a division of the B. F. Goodrich Company, Watertown, Mass. In World War I, Mr. Blanchard served as a sergeant in the Chemical Warfare Service. During the recent war, he was a member of the Greater Boston War Manpower Committee and the Mayor's Citizens' Committee. He also served on the National War Stabilization Board for Region I, and for several years was a member of the Committee on Industrial Relations for the Boston Chamber of Commerce. He is a director of the First National Bank of Malden, of the Norfolk and Dedham Mutual Fire Insurance Company, Dedham, and of the Massachusetts Safety Council, and a trustee of the Melrose Savings Bank, Melrose, Mass. In his professional field, Mr. Blanchard is a member of the executive committee of the Executive Club of the Boston Chamber of Commerce; the manufacturing committee of Rubber Manufacturers' Association, Inc.; the American Institute of Chemical Engineers; American Chemical Society; and the Engineering Societies of New England. He has also been active in alumni affairs and was vice-president of the Alumni Association, 1944–1945; member of the Visiting Committee on the Department of Economics and Social Science, 1940–1946; chairman of the M.I.T. Alumni Postwar Placement Committee; and chairman of Alumni Day, 1942.

Alumni Day, 1947

RAPID strides are being made in the preparations for Alumni Day, Saturday, June 14, when Technology Alumni will return to their alma mater for a luncheon in the Great Court, an afternoon session on "Aviation: Today and Tomorrow" at which leaders in the aviation field will speak, an inspection of laboratories, informal departmental receptions, and the popular and informal "Stein-on-the-Table" banquet at the Hotel Statler in the evening. Many classes whose numerals end in two or seven will hold reunions in conjunction with Alumni Day. The interests of wives of Alumni who attend class reunions and Alumni Day activities will be taken care

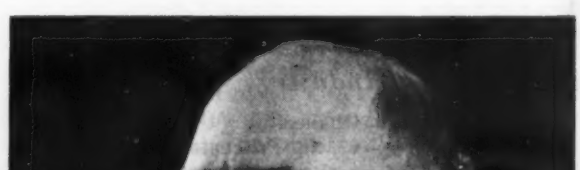


Photo by the Phillips Studio

Photo by George M. Cushing, Jr.

TO THE CORPORATION

. . . for a five-year term as representatives of the Alumni Association, the National Nominating Committee has selected three prominent Technology graduates. From left to right they are: James McGowan, Jr., '08, V, President of the Campbell Soup Company, Camden, N. J.; Harold Bugbee, '20, X, XV, President of Walter B. Snow and Staff, Inc., Boston; and C. George Dandrow, '22, IX-B, Vice-president and General Sales Manager, Industrial Products Division, Johns-Manville Sales Corporation, New York City.

of by an entertaining program for the ladies, who will also have a banquet of their own.

Parke D. Appel, '22, Alumni Day chairman, announces that plans for the development of Alumni Day activities are in the hands of ten well-selected committees now putting forth their best efforts to create an outstanding occasion. The membership of these committees is as follows: *Banquet:* William W. Garth, '36, chairman, Edmund B. Fritz, '32, James B. Smith, '32, Robert L. Johnson, '38, and John L. Danforth, '40; *Class Day:* John A. Hrones, '34, chairman, Eugene Mirabelli, '19, and George A. Wilson, 10–44; *Exhibits:* Herbert L. Beckwith, '26, chairman, John R. Markham, '18, John E. Burchard, '23, Edward S. Taylor, '24, C. Fayette Taylor, '29, and Gyorgy Kepes, Staff; *Ladies' Program:* Mrs. William H. McAdams, chairman, Mrs. Parke D. Appel, Mrs. Charles B. Breed, Mrs. Harold Bugbee, Mrs. Karl T. Compton, Mrs. Bradley Dewey, Mrs. Leicester F. Hamilton, Mrs. J. Rhyne Killian, Jr., Mrs. Larcom Randall, Mrs. Earl Stevenson, Mrs. Albert N. Walker, Mrs. Glenn C. Williams, and Mrs. Henry E. Worcester; *Luncheon:* John B. Wilbur, '26, chairman, A. Flint Taylor, '26, William J. Kirk, '28, and Ariel A. Thomas, '36; *Publicity:* Ralph T. Jope, '28, chairman, Henry B. Kane, '24, George I. Chatfield, '28, James Donovan, '28, Beverly Dudley, '35, and John J. Rowlands, Staff; *Registration:* Wolcott A. Hokanson, Staff, chairman, John N. Higgins, '31, and Donald P. Severance, '38; *Symposium Arrangements:* Donald Whiston, '32, chairman, Albert J. O'Neill, '32, Joseph Bicknell, '34, and William L. Root, '43; *Transportation and Hotel Accommodations:* Emmons J. Whitcomb, '11, chairman, Malcolm S. Stevens, '34, and R. Dixon Speas, '40; *Ways and Means:* Delbert L. Rhind, Staff, chairman, Carl M. F. Peterson, '29, and Horace S. Ford, Staff.

Professor Jerome C. Hunsaker, '12, will act as the presiding chairman at the symposium where internationally known leaders will discuss "Aviation: Today and Tomorrow." In keeping with the theme of the symposium, the exhibits, lectures, and displays at the Institute will place special emphasis on aeronautics. There will be demonstrations in the Wright Brothers Wind Tunnel and the Gas Turbine Laboratory, and exhibits on communications and navigational aids in aeronautics will be displayed throughout the Institute.

At 7:00 in the evening the Hotel Statler will be the scene of the ever popular M.I.T. banquet. There will be stimulating addresses, of course. In addition, those who attend the banquet will receive a newly designed stein to add to those of former years as a memento of the memorable occasion of Alumni Day, 1947.

As usual, Alumni Day has been planned in conjunction with commencement exercises which take place on June 13.

Faculty Appointments

RECENT appointments to the staff with the rank of professor include William T. Martin, Mathematics Department; and Lieutenant Colonel Kenneth W. Holbert, Military Science Department.

Appointments to associate professorships include Lieutenant Colonel Raymond S. Crossman and Major Jack F. Lane, both of the Military Science Department; and Leo L. Beranek, Electrical Engineering Department.

New appointments to the rank of assistant professor are Major John C. Bolton, and Captain W. T. Whittemore of the Military Science Department; and Edmond P. Garvey, Electrical Engineering Department.

Rodney H. Smith, '43, has been promoted to the post of Assistant Professor in Aeronautical Engineering.

Technical Director of Acoustics

THE appointment of Dr. Leo L. Beranek, formerly director of the Electro-Acoustic and the Systems Research Laboratories of Harvard University, as Associate Professor of Communications Engineering and Technical Director of the Institute's Acoustics Laboratory, has been announced by President Compton. As technical director of the Acoustics Laboratory, Dr. Beranek will represent the Electrical Engineering Department, collaborating with Dr. Richard H. Bolt, who is director of the Acoustics Laboratory.

Dr. Beranek is a native of Solon, Iowa, and was graduated from Cornell College, Iowa, in 1936. He then entered Harvard University for graduate studies and was awarded the degree of Master of Science in 1937 and his doctorate in 1940. Dr. Beranek was an instructor at Harvard from 1940 to 1943 when he was appointed director of the Electro-Acoustic Laboratory. From 1945 to 1946 he also held the post of director of the Systems Research Laboratories. In that year he was appointed a John Simon Guggenheim Fellow, and has since carried on advanced studies at Harvard and at the Institute.

During his graduate career at Harvard, Dr. Beranek held the Gordon McKay Scholarship from 1936 to 1938 and the Parker Fellowship from 1939 to 1940. Last year Cornell College awarded him the honorary degree of Doctor of Science.

Dr. Beranek has won wide recognition as an authority in acoustics and communications engineering, and has made notable contributions in theoretical and applied acoustical science. He is represented in the literature of acoustics by numerous papers and articles. In 1944 he was presented with the biennial award of the Acoustical Society of America for outstanding contributions to acoustics.

Dr. Beranek is a fellow of the American Physical Society and a fellow and member of the editorial board of the Acoustical Society of America; a senior member of the Institute of Radio Engineers, and a member of the American Association for the Advancement of Science, as well as Sigma Xi.

Report on Mechanical Engineering

THE Visiting Committee on the Department of Mechanical Engineering * met at the Department headquarters on April 2, 1946. The Committee inspected the space and facilities at present assigned to the Department with reference to current utilization and future changes and developments. In particular, the Committee visited the several laboratories of the Department, met the staff member in charge of each, and discussed the function of each laboratory in the educational program of the Department. The laboratories visited were those devoted to Machine Design and Drawing, Dynamics and Control, Fluid Mechanics, Cavitation, Heat and Power, Heat Transmission and Measurement, Mechanics of Materials, Plasticity, Testing Materials, Fatigue, Stress Measurement, Mechanical Processing, Machine Tools, Refrigeration, Air Conditioning, Sloan Automotive and Aircraft Engines, and Gas Turbines.

* Members of the Committee for 1945–1946 were: B. Edwin Hutchinson, '09, chairman, Norman D. MacLeod, '14, George J. Mead, '16, Charles A. Chayne, '19, William H. Collins, Kenneth H. Condit, and Ralph E. Flanders.

On February 1, Dr. Leo L. Beranek assumed new duties at the Institute as Associate Professor of Communications Engineering and Technical Director of the Acoustics Laboratory.

In the afternoon of the same day, the Committee discussed with members of the Department and with representatives of the administration the postwar plans for modernization and expansion of certain laboratories, the introduction of new subjects of instruction, additions to the staff, and the relation between the undergraduate and graduate curricula.

The Committee fully approves the Department's plans for its future development and, within the limit of funds available, recommends full support for the modernization of the Mechanical Processing and Machine Tool laboratories. The housing of these two laboratories in the same building is desirable. The Committee recommends the development of these laboratories toward offering instruction, not only in the mechanics of machine tools and of the welding, forging, forming, and casting operations involved in manufacturing, but also in the physical and metallurgical effects of such operations, including metal cutting. There appears to be an opportunity to unify the concepts involved in altering the shape of metal by utilization of basic ideas both from mechanics and from metallurgy. To this end, closer co-operation with the Department of Metallurgy is recommended. Eventually, work of graduate school level should be offered.*

It is understood that both the Department of Aeronautical Engineering and the Department of Naval Architecture and Marine Engineering are interested in having

(*Concluded on page 288*)

* The recent establishment of the Mechanical Metallurgy Laboratory under the directorship of Professor John Wulff of the Department of Metallurgy fulfills this recommendation.

POWER
FLOWS THROUGH
COPPER
AND ITS
ALLOYS

CYCLOTRON . . . Winding a coil for a cyclotron, using Revere copper strip, held to close tolerances on size and finish. Thousands of pounds of such copper are required for the coils that produce the tremendous magnetic field required in an "atom-smasher."

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THE INSTITUTE GAZETTE

(*Concluded from page 286*)

their students obtain better instruction in the performance of modern machine tools. To improve the instruction given, it will be necessary to replace old tools by modern types of greater power and rigidity. This is being done by acquisition of war surplus machinery from the government.

It is recommended that the instruction eventually be developed to include the principles of jigs and fixtures and the action of the cutting edge. Also within the limits of available funds the Committee recommends the modernization and enlargement of the Sloan Laboratories for Aircraft and Automotive Engines. The generous support of Alfred P. Sloan, Jr., '95, has made possible timely alterations to permit a larger number of students to take advantage of this unique facility. The Committee believes that automotive engineering is a most important branch of mechanical engineering and that the Institute's instruction and research in this field should continue to be kept in a leading position.*

The Committee notes with satisfaction that the Visiting Committee on the Department of Aeronautical Engineering succeeded in raising funds from industry to provide a Gas Turbine Laboratory, to be used jointly by the Aeronautical Engineering and Mechanical Engineering departments for graduate instruction. The Committee also notes with approval that additional staff members have been engaged.

*This modernization is now being carried out.

The Committee suggests that consideration be given to the use of visual aids in teaching, such as have been found helpful in Army and Navy war training courses. Visual aids, such as models, slide films, moving pictures, and animated drawings might prove useful for presentation of information and descriptive matter to large classes and for illustration of processes.

The Committee devoted considerable time to a consideration of the objectives of the Course in Mechanical Engineering. It recommends that continuing efforts be made to attract superior students to the Graduate School by the offer of special opportunities for instruction and research, by scholarship aid, and above all by having teachers of outstanding ability. It further recommends that steps be taken to control the number of seniors so that adequate laboratory facilities are available for graduate students.

The Committee heartily endorses the Department's plan for splitting the senior curriculum into two options: the General option, emphasizing practice, for those students who intend to go directly into industry; and the Engineering Science option, emphasizing analysis, for those who show an aptitude for advanced study leading to design and research.

The Committee is gratified that its previous suggestion regarding instruction in production has resulted in an elective course in the Department of Business and Engineering Administration available to Mechanical Engineering seniors and others.

Photo by Empire

The annual meeting of the American Society of Civil Engineers provided opportunity for Technology Alumni in the civil engineering profession to get together for an informal luncheon at the Hotel Commodore on January 16, 1947. The luncheon, arranged by the Technology Club of New York, was attended by 92 engineers, educators, and executives. Seated (left to right) at the head table near the far wall are: George E. Barnes, '23, Head of the Department of Civil Engineering at the Case School of Applied Science; Rear Admiral William H. Smith, '15, chief of the design section, Bureau of Yards and Docks, United States Navy; John B. Wilbur, '26, Head of the Department of Civil Engineering at M.I.T.; William H. Mueser, '22, partner, Moran, Proctor, Freeman, and Mueser, and Vice-president of the Technology Club of New York; Charles B. Breed, '97, former Head of the Department of Civil Engineering at M.I.T.; Allan R. Cullimore, '07, President, Newark College of Engineering; William E. Stanley, Professor of Sanitary Engineering at M.I.T.; Hale Sutherland, '10, Head of the Department of Civil Engineering at Lehigh University; C. George Dandrow, '22, Vice-president, Johns-Manville Corporation, President of the Technology Club of New York, and Vice-president of the M.I.T. Alumni Association; Alfred T. Glassett, '20, Vice-president, W. J. Barney Corporation. Members of the instructing staff of the Department of Civil Engineering who attended the luncheon are (in addition to those at the head table): Thomas W. Lambe, 2-44, Professor Donald W. Tyler, '34, Professor Arthur T. Ippen, Professor James W. Daily, Professor Clair N. Sawyer, and Professor John B. Babcock, 3d., '10. Also present and active in M.I.T. activities were Walter D. Binger, '16, Vice-president, City Investment Company, and member of the Visiting Committee on Civil Engineering; William H. Latham, '26, Park Engineer, City of New York; and Arthur L. Shaw, '09, partner, Metcalf and Eddy, and contact member of the student chapter of the American Society of Civil Engineers.

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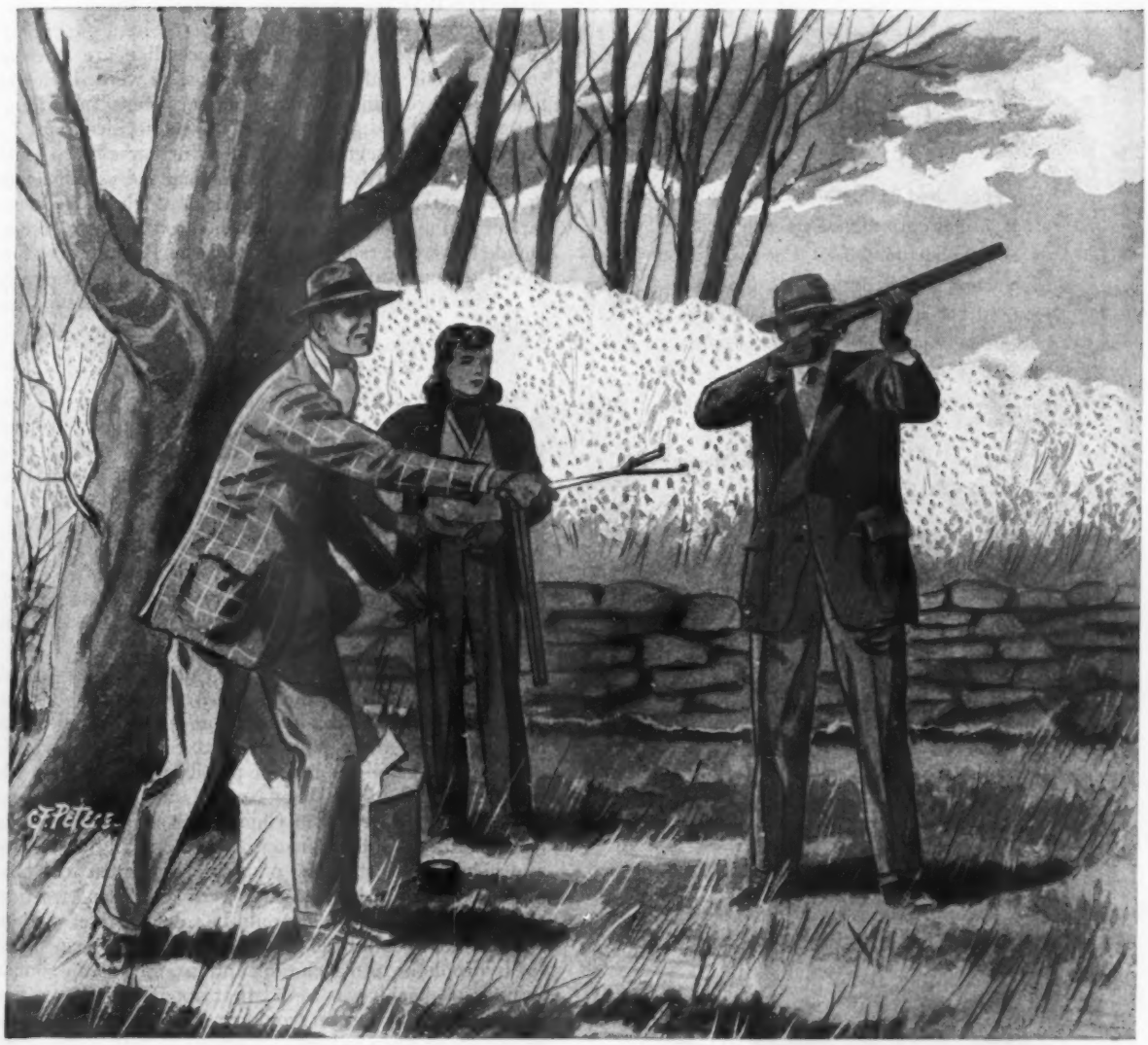

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PISCATORIAL CONCERTO

(*Continued from page 272*)

and Development, called the conference of April 1 to decide the direction in which further research on underwater background noise should proceed. Some four dozen specialists in acoustics, representing various Navy laboratories as well as industrial and academic groups working under O.S.R.D. contracts, participated in the conference. The approach finally agreed upon was indirect but logical. It was to study fish noises in accessible areas where oceanographic and biological conditions were similar to those which obtained in more active waters. In order to put the results to greatest use, it was decided that, by experiments on segregated fish, a further effort should be made to identify various biological noises picked up in open water. Commander Charles J. Fish, an oceanographer and marine biologist attached to the Navy, recommended the waters of Florida and the Bahamas for further listening studies since these correspond most closely in marine life to the coral reef areas near the Japanese Islands.

War Work in an Aquarium

As a result of the conference, the Navy assigned the studies on segregated fish to the Naval Ordnance Laboratory, and the measurement of the noise off Florida was made a joint project for the San Diego laboratory, the New London laboratory, and the Naval Ordnance Laboratory. Segregation work was pursued at the Shedd Aquarium in Chicago and also at the United States Fishery Biological Laboratory at Beaufort, N. C. For the studies in the Gulf Stream, the Navy used a 90-foot yawl, the *Odyssey*, painted it gray, and renamed it the U.S.S. *Saluda*.

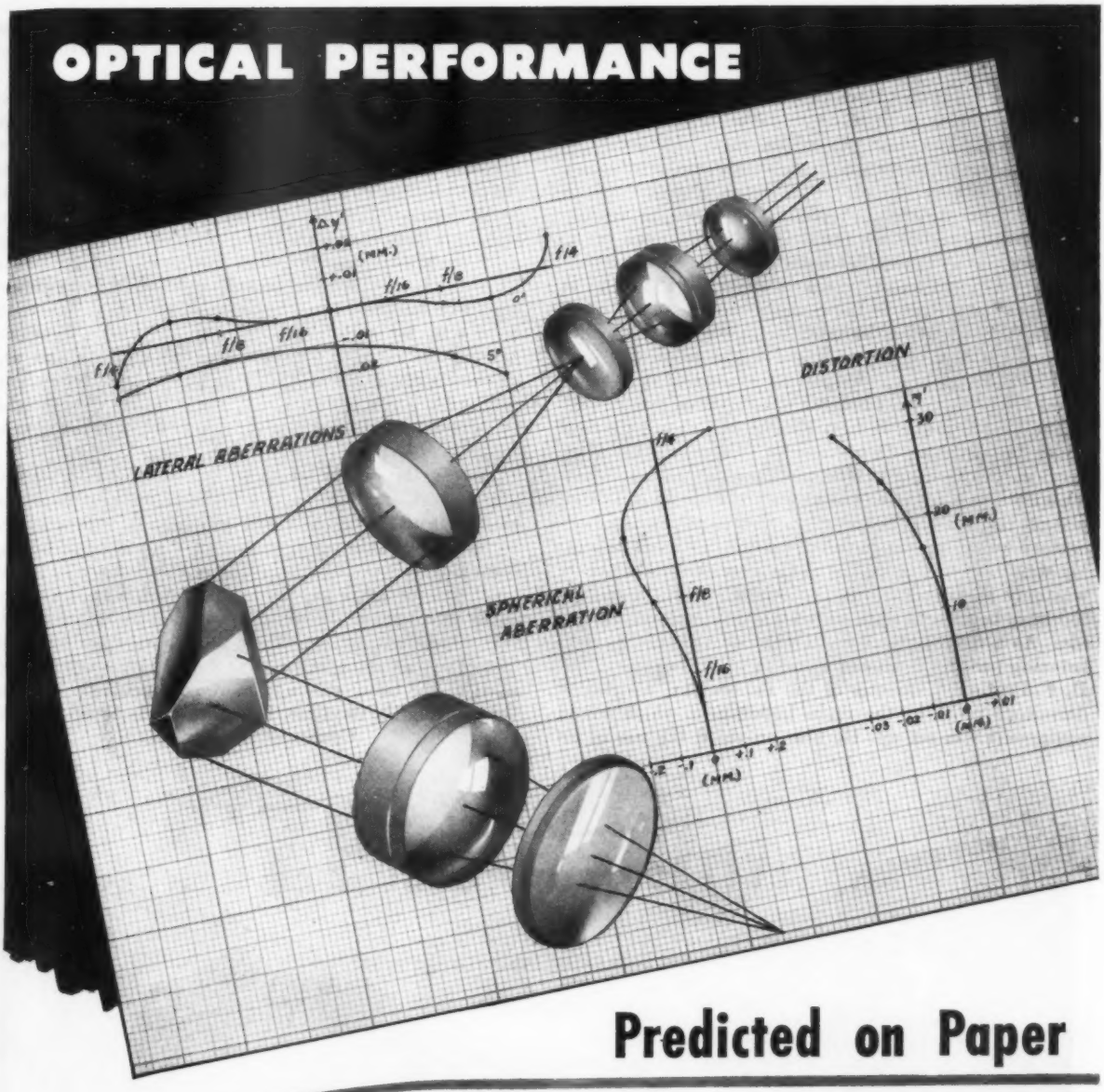
By a long distance telephone call to Walter Chute, enterprising director of the Shedd Aquarium in Chicago, arrangements were made to listen to fish there with equipment from the Naval Ordnance Laboratory. His promise to give all the help he possibly could was no idle indulgence in rhetoric. When Naval Ordnance Laboratory representatives arrived in Chicago with sound recording equipment, he put his men to work opening the crates and helping to install 800 pounds of apparatus. Meters, amplifiers, and a disc recorder were set up on two tiers of a movable table, which could be rolled with ease down the corridors behind the exhibition tanks. By suspending the hydrophone into each tank and listening to the sounds from a speaker, it was found that about half the marine species in the aquarium would make noises, either spontaneously or when induced by proper stimuli. Some, such as the triggerfish and sting ray, would make a noise only while eating, at which time crunching sounds from the speakers would resound throughout the aquarium's rear galleries. Other species, such as the red drums and croakers, would sound off only when frightened with a net. The old 300-pound black drum, a resident of the aquarium since 1930, would give out his characteristic boom only when nudged with a mop.

Piscatorial Concert "At Home"

All through our experiments, Mr. Chute would watch us work and listen to his fish perform over our speaker. He was genuinely gratified that the Shedd Aquarium had

(*Continued on page 292*)

OPTICAL PERFORMANCE



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PISCATORIAL CONCERTO

(*Continued from page 290*)

been selected for this research program. It was difficult, he said, for an aquarium director to feel very useful when a war was going on, and this collaboration with the Navy provided a rare opportunity to make a direct contribution.

At Beaufort, N. C., where work was in progress from June to August, 1943, an effort was made to arrange conditions in such a way that the fish, although segregated, would feel more "at home" than in an aquarium. The Government had established a marine laboratory at Beaufort at the turn of the century because of the great density and variety of aquatic life in the shallow, bank-protected waters of Bogue Sound. Most tropical species could be found here, along with numerous cold-water forms having a normal habitat much farther north.

The United States Fishery Biological Laboratory, now under the Interior Department's Fish and Wild Life Service, occupies an old-fashioned, rambling frame building surrounded by groves of yucca trees on Piver Island, just off the town of Beaufort. In normal times, the Laboratory would have been full of marine biologists dissecting sting rays or sharks, but in the summer of 1943 there was only a small handful, the others having been kept too busy because of accelerated wartime teaching schedules. As a result, the Naval Ordnance Laboratory fish-listening party was almost alone at the Laboratory. Dr. H. F. Prytherch, director of the Laboratory, assigned a dormitory room in the main building in which sound equipment was set up. He also provided the use of an abandoned mullet pond about 1,000 feet away to house the fish specimens whose noises were to be identified and recorded, if possible.

After considerable difficulty, two local commercial fishermen with a boat were hired to bring in, alive and in good condition, stocks of fish for the experiments and recordings. Using chicken wire, four areas were enclosed within the mullet pond so that a different species would be segregated in each of the enclosures. The hydrophone was hung from the side of each pen in turn, and recordings were made of whatever noises the catch yielded. When work with one species was completed the specimens would be removed from the enclosure and the fishermen were sent for a different type of fish as replacement. During the course of this work, the mullet pond was stocked with croakers, toadfish, hogfish, sea robin, catfish, spot, perch, and black drum. Noises were recorded on phonograph discs whenever a species turned out to be sound producing.

During the course of these recordings in segregated regions of the mullet pond, a hydrophone was kept suspended from the end of a pier below the instrument room to record any interesting noises that could be picked up from Bogue Sound. Invariably one could hear the crackling noise of snapping shrimp, which found the oyster shells and mud of the shallow bottom an exceptionally favorable environment. Then there were the drum rolls from croakers and other drumfish which were audible most of the time, although more conspicuously at night than during the daytime. Drumfish are believed to make

(*Continued on page 294*)

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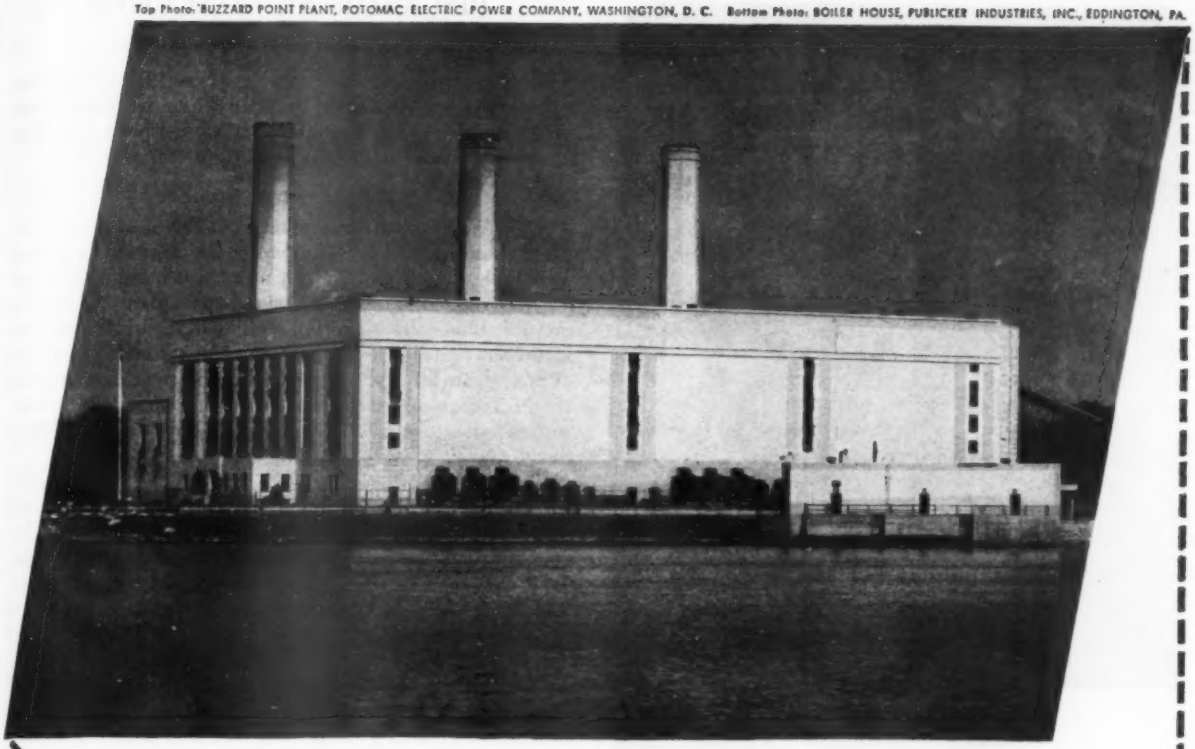

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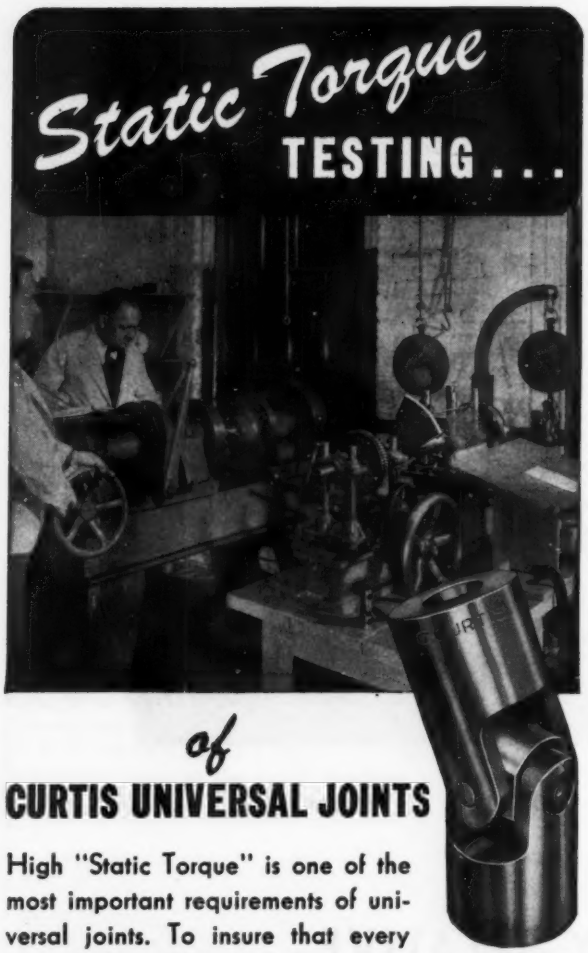

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PISCATORIAL CONCERTO

(*Continued from page 292*)

their machine-gun like noise by special "drumming muscles" which beat rhythmically against their swim bladders and which probably act as resonant sounding boards for transmitting the sound into the water.

Unco-operative Stentor

Strangest of all the noises heard at Beaufort was a low-pitched, intermittent musical toot, which could be picked up in the water almost any time. Each burst would last for half a second and would be repeated about 15 times a minute. This noise was often audible in the air to someone standing on a pier projecting over the water. The natives of the region always insisted that the sound came from toadfish, but when toadfish were placed in the experimental enclosures in the mullet pond no sound from them at all was ever heard.

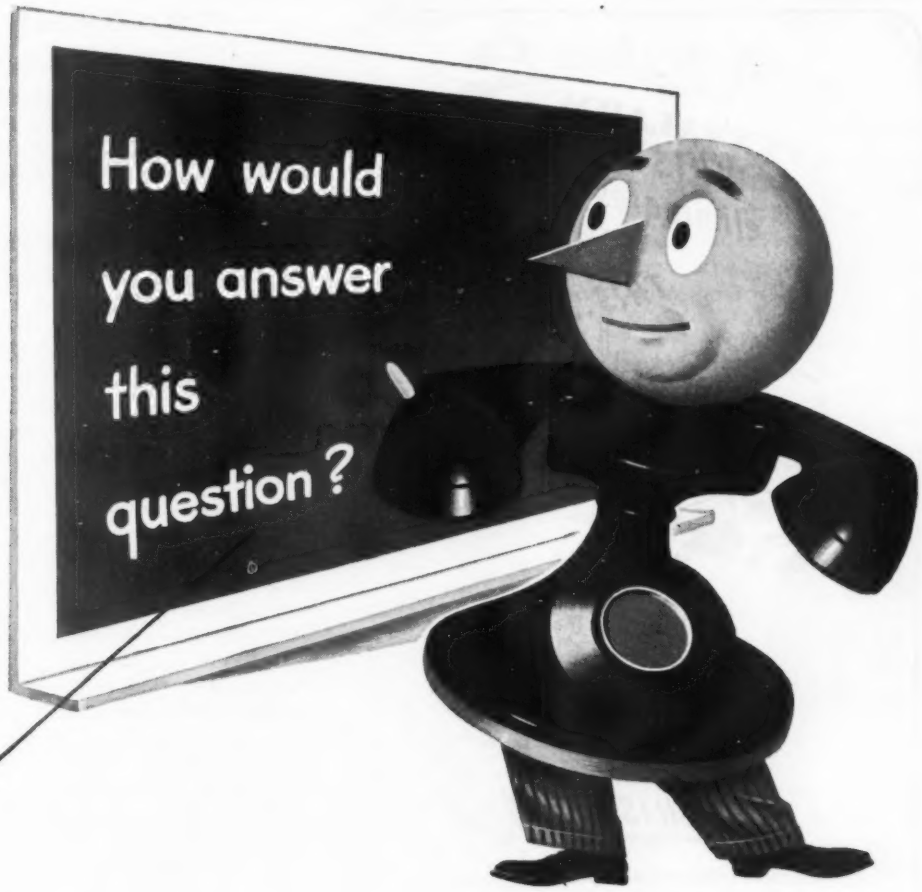
Toadfish are queer in many ways. They are sluggish, ill-tempered, repulsive looking creatures who build nests under rocks or in pieces of pipe on the bottom and lay eggs in them. The male toadfish is said to guard the eggs for a week or two at a time and, according to local fishermen, makes his characteristic noise as a means of warning intruders to stay away. For more than a month we listened in vain to the toadfish cage in the mullet pond and finally decided that if toadfish made any noise at all they surely would not do so in captivity.

Then one evening the noise level meter from the hydrophone on the pier swung far off scale every time the musical toot was heard over the loud-speaker. This indicated that the source of the noise was much closer to the hydrophone than it had ever been before. The next day the noise was just as loud, indicating that, whatever it was, the source had probably not moved during the night. The hydrophone was unfastened from its mooring on the pier and was moved around in the water until it was closest to the sound source as indicated by maximum reading of the sound level meter. A diving helmet was borrowed from the nearby Duke University Marine Laboratory, a boy was engaged to operate the pump, and the bottom, 12-feet deep at the point where the hydrophone indicated the source of the noise to be, was explored. But the water was too murky to permit anything at all to be seen; in this case the direct approach was doomed to failure.

Finally, after the noise had continued to come, apparently, from the same spot for a week, a new technique of identification was tried. A crab trap, baited with dead fish, was lowered from the end of the pier over the point where the noise was loudest. It was down only a minute or so when the noise stopped coming over the loud-speaker. When the crab trap was pulled up, a fat, sullen looking toadfish was inside. It was kept in the experimental pond for days and although the subject of frequent listening observations, never again produced musical toots. However, no longer did the loud tooting noise come from the spot under the pier.

The toadfish noise, if we may call it such, on the basis of so circumstantial an identification, had a tremendous volume — one that was much higher than that registered from any other species studied. It seems highly probable that the male toadfish could well guard his eggs by simply frightening any intruding outsiders with the very high

(*Continued on page 296*)



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PISCATORIAL CONCERTO

(*Continued from page 294*)

sound pressure he generates. According to zoologists, the steam whistle sound is made by special muscles that stroke the swim bladder in the same way that one can make a squeaking noise by stroking a wet, inflated balloon with one's finger.

Unexpected "Bronx Cheer"

Other species made noises which could be identified more directly. The hogfish makes a grunting noise by gnashing his pharyngeal teeth. The reddish color sea robin * makes a noise that sounds somewhat like a hen cackling in a barnyard. It is believed to make its noise by the same mechanism as that attributed to the toadfish. The catfish makes a sound like an African tom-tom beat, with about the same cadence. It is said to produce sound by beating its vertebrae together, but this view is doubted by authoritative biologists. The spot made a sound consisting of a series of raucous honks more like a "Bronx cheer" than anything else. This species belongs to the same family as the croaker, but its noise is of considerably different timbre. The sound was found to carry not more than five feet underwater, while the noise from a single croaker was picked up more than 25 feet away.

Suspecting that sea trout were important contributors to the noise heard in East Coast bays and sounds, we tried hard to get some for our segregation studies in the mullet pond. Unfortunately, sea trout were not in season around Beaufort during our stay there, but they were said to be prevalent in Albermarle Sound about 25 miles north, so our fishermen went north on an overnight trip. They returned with 300 trout for us, all of which were dead. The fish had been thrown into a large wooden tank through which, on the way home, the fishermen tried to circulate sea water, by pouring bucketsful in at the top and letting it out through a stopcock at the bottom. Although the men on this bucket brigade made a strenuous effort, they were not able to circulate the water in a manner pleasing to the trout, which popped to the surface, one by one, bellies up. We never did find out just what trout noises sound like.

After the segregation tests were completed, it was decided to record and measure the noises heard in the open sea outside of Beaufort Inlet. Local fishermen had spoken of an area off Cape Lookout where fish were especially plentiful and it seemed that it would be worth while to listen there. Accordingly, permission was obtained from the officer in charge of the nearby Morehead City Section Base, to take some listening and recording gear out on an 83-foot Coast Guard patrol vessel. Two overnight trips were made: one to Cape Lookout Light and the other to a fishing ground about 25 miles offshore.

At this time, Gene Irish, a woman physicist from the Naval Ordnance Laboratory, was helping with the fish noise work. Because of a Navy regulation forbidding women to be on any naval vessel when it is under way, she was not allowed to go out with the 83-footer. Much to the surprise of the crew, however, permission was obtained for her to board the boat before it left and help in setting up the apparatus. Because no more suitable space

(*Continued on page 298*)

* The word robin is akin to an old high German word meaning bright and is applied to numerous birds and flowers as well as to fish.

21 Years of Comfort in the Adirondacks

THE QUEENSBURY HOTEL, GLENS FALLS, N. Y.
Formerly the New Glens Falls Hotel. Built in 1925. Architect, J. G. White Engineering Corporation. Owner, Glens Falls Hotel Corporation. Heating Modernization program and installation of "control-by-the-weather" Webster Moderator System by Erwin C. Martin, Glens Falls heating contractor.

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The Queensbury Hotel was built in 1925 and equipped with a Webster Vacuum System, including Webster Traps and Valves and a Nash Vacuum Pump, designed to provide all the heat necessary to meet severe Adirondack winters.

In 1944, the hotel owners decided upon a heating modernization program. This program included covering exposed risers to increase mild weather comfort and permit effective control; 2-zone Webster Moderator System with automatic "control-by-the-weather"; reduction in heating supply to unoccupied rooms; improvements to promote steam economy in hot water and kitchen services.

In less than six months, the demonstrated results in improved heating at lower cost were so outstanding that the hotel owners completed payment for the Moderator System for cash.

Earl S. Martin, Manager, Queensbury Hotel, Glens Falls, N. Y.

The heating results achieved in the Queensbury Hotel were not due alone to the changes and the Webster Moderator System Equipment — a first class installation job by heating contractor Erwin C. Martin of Glens Falls, competent operation by S. R. Bradley, Building Engineer, and cooperation in assuring effective use of the equipment by hotel personnel under the direction of Manager Earl S. Martin, were all equally vital.

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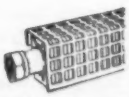

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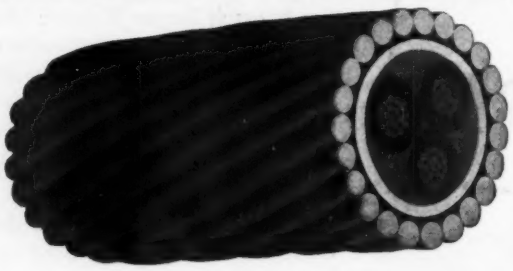

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PISCATORIAL CONCERTO

(*Continued from page 296*)

could be allotted for our equipment amplifiers and meters were installed on the bunk of the Chief Boatswain's Mate. Between meals, the disk recorder occupied the place of distinction on the mess table. The Chief slept in the fo'c'sle in an absent crewman's sack and was surprisingly cheerful about the inconvenience which the advancement of science made his lot. During an all night listening vigil, recordings were made whenever anything interesting could be heard.

Ultrasonic Shrimp

Early in the evening when we were at anchor over the fishing ground, a new kind of high pitched, drilling noise came over the loud-speaker. The noise resembled that of a croaker, but it had a much more metallic timbre and the drum rolls were spaced more closely. The noise increased in intensity as the evening wore on. It had not been heard in Bogue Sound, and only after observations were completed and a search of the literature could be made in Washington, was the noise circumstantially identified as coming from the bastard trout. This tiny fish, said to be common in the waters several miles off the Carolina Coast, is never found in the bays and sounds. Since the bastard trout is a member of the drumfish family, like the croaker, and since its noise had the high pitch that would be expected of a very small specimen, this identification, circumstantial as it was, appeared reasonable.

During the time the program at Beaufort was in full swing, the *Saluda* had been recording water noise at several dozen stations off the Florida Coast and in the Bahamas. When the original schedule had been completed, it was decided to extend the *Saluda's* program by a cruise up the East Coast to New London, Conn. One of our principal tasks on this cruise was to locate snapping shrimp which were believed to be somewhere along the North Carolina Coast, and to determine the northern limit of their occurrence along the Atlantic Coast. Shrimp were discovered as far north as the neighborhood of Cape Hatteras, but not before the *Saluda* had blundered, fortunately without mishap, into an offshore mine field laid to create a safe "pocket" in which convoys could anchor at night. After having listened to the captive fish in the mullet pond at Beaufort, it was especially interesting to be able to identify various noises off Wimble Shoals as coming, for example, from spot or sea robins.

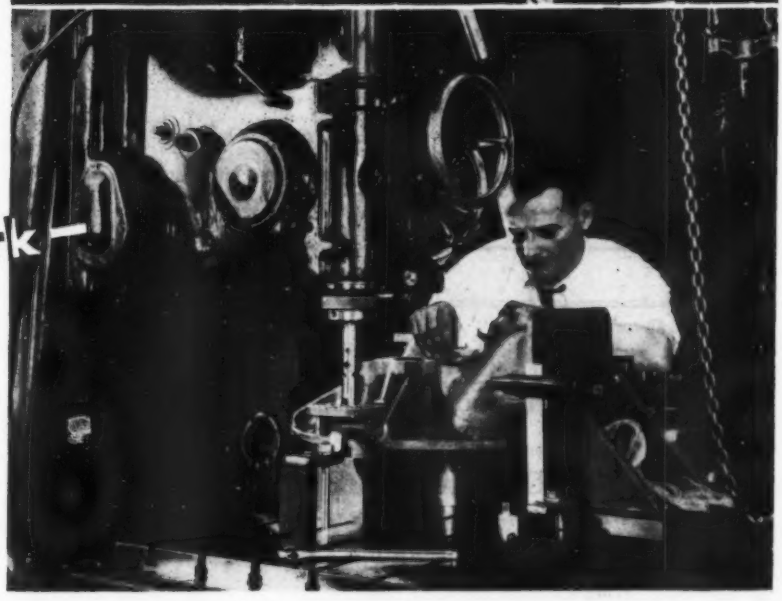
Anchoring and floating our hydrophones at four stations between Jacksonville and Norfolk, we made the distance in seven days, using wind power when we could and a small auxiliary at other times. There were 12 aboard: three officers, five sailors, and four civilians. Crossing the convoy lanes between Norfolk and Montauk Point on our way to New London, the civilians had the unusual experience of reinforcing the naval personnel in standing watch, maneuvering the sails, and handling the wheel.

The New Izaak Walton

There will never be any way for us to know exactly how much noisy fish actually interfered with acoustic gear used under combat conditions. We know that off

(*Continued on page 300*)

Contract Manufacturing



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PISCATORIAL CONCERTO

(*Continued from page 298*)

Japan and other Pacific islands, our submarines took advantage of the crackling of shrimp, hiding under its cover to evade enemy echo-ranging equipment. Japanese mining officers, interrogated by American scientists on technical missions, reported spontaneous explosions in Tokyo Bay which were attributed to drumfish getting too vociferous around acoustic mines we had laid in the Bay. We now know that the Japanese themselves had a great deal of difficulty with spurious noises in their own sound equipment. It took them more than a year to track the source of the interference to noisy fish, and when their biologists began a systematic study of the subject in 1944 they were bombed out of every experimental station they had established for the purpose.

Now that the war is over, we may well ask whether the wartime work the Navy did on fish noise is likely to have any useful peacetime application. Although the full extent of civilian uses may require extended development over a long period, two possible uses are immediately evident; a scientific application and a commercial one. Techniques and equipment developed by the Navy can be employed as tools for marine biologists to study the population, distribution, movements, migrations, and behavior characteristics of soniferous fish species. The United States Fish and Wild Life Service, as well as the biological surveys of states along the seacoast, spend millions of dollars each year to investigate such matters. A few thousand dollars invested in underwater sound equipment might well lead to substantial returns in advancing this important study.

More extensive are the possibilities of using the noise made by fish as an aid in catching them commercially. In deep water trawling operations, for example, it would be extremely helpful to the fishermen if they could have something more reliable than "a hunch" to tell them where to lower their nets. Sound-producing fish generally travel in schools which announce their presence only by acoustic means.

At its present stage, however, it is not likely that the submarine sonic technique would be entirely practical for commercial fishing. A very important consideration is that all species of value as food are not noisemakers; north of New Jersey almost none makes noise. Thus the

(*Concluded on page 302*)

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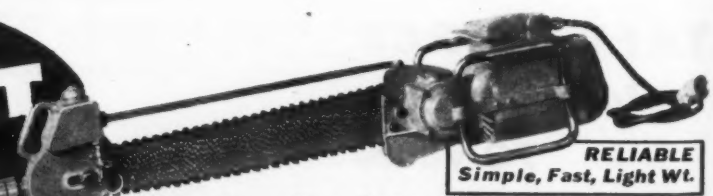

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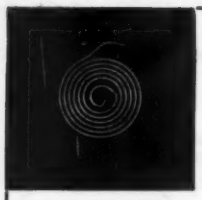

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PISCATORIAL CONCERTO

(*Concluded from page 300*)

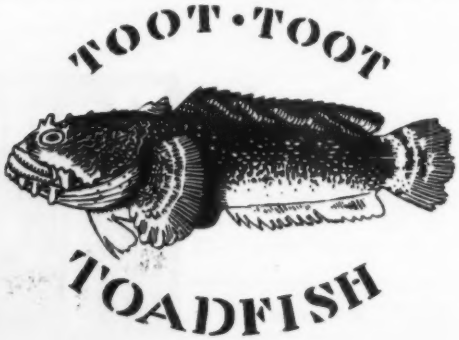
absence of sound would not necessarily imply the absence of food fish. Many soniferous species have a tendency to sound off only at night and this is not the best time for most fishing operations. Finally, it must be recognized that the necessary equipment might be too expensive for the average commercial fisherman and too difficult for him to operate effectively.

In spite of these difficulties, several manufacturers of marine equipment have indicated their intention of putting on the market listening kits for fishermen. Perhaps this presages the day when every fisherman will have to be a sound engineer or physicist, in addition to being a navigator and weather prophet. Fishing would then become so complex that if Izaak Walton returned to earth he would, as an exponent of the simple life, have nothing more to do with it. Whether fishing by hydrophone will ever supersede fishing by "hunch" depends mainly, however, on which can be proved to yield the largest catch. If listening for fish turns out to be an effective way of bringing them in, the day may not be far off when a hydrophone becomes as much an integral part of the equipment of a fishing boat as its anchor or net.

Acknowledgments

The Navy's investigation of biological underwater noises was, as has been pointed out, carried on by a large number of engineers, physicists, and biologists associated with several different war research activities. It is not possible to name them all here, but certain individuals whose contribution was outstanding should at least be mentioned. Measurements at the San Diego laboratory were undertaken by its Listening Section, with F. A. Everest in charge. The biological work there was done by Dr. Martin Johnson. Investigations in this field at the New London laboratory were under the direction of Donald Loye, assisted by Don A. Proudfood and Robert Wagner.

The measurements made by the Naval Ordnance Laboratory on fish noise off Cape Henry were conducted by L. C. Bell, George Brown, and Lee Swart. Wayland Loomis participated in the Shedd Aquarium work and that on the U. S. S. *Saluda*. Robert Grunwald took part in the work at Beaufort. Others are named in the body of the article. It should be borne in mind that all of the work here described was, as almost all war research, not a matter of individual effort but of considerable teamwork, where the ship's cook was, for example, as important a contributor as the scientist in charge of the party.



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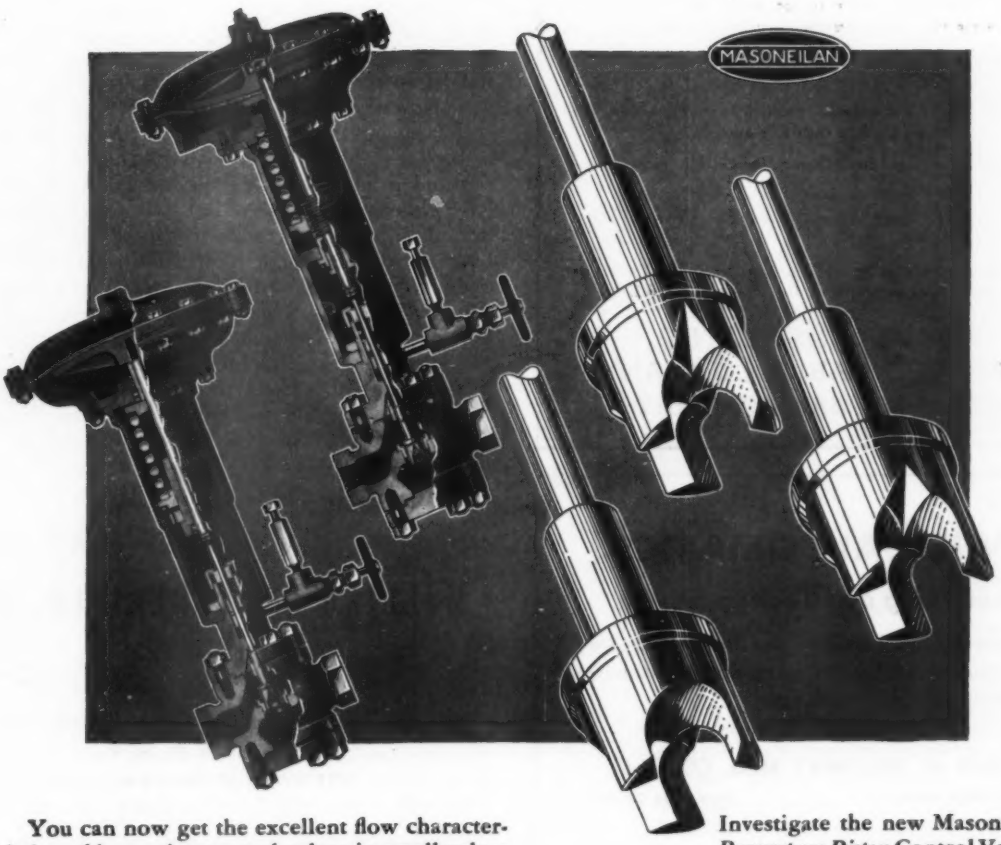

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TOO FEW, TOO LATE

(*Continued from page 282*)

and the rocket motor. The control surfaces were attached to the bottom end of the four-tail stabilizer fins.

The *Waterfall* rose vertically, but it is doubtful whether this rocket was actually used. Records of some four dozen experimental launchings have been found, but since these records also stated that the rocket was a "full success" in only 12 cases, obviously much development work had still to be done.

A very interesting weapon was the rocket *Taifun* (*Typhoon*) which was meant for antiaircraft barrage fire, a counterpart of the British Z-guns. The *Typhoon* had a straight cylindrical body, with ogival head and rather small tail fins. It stood 75½ inches high; the diameter of the body was four inches; and the diameter over the tail fins was eight and one-half inches. The ogival head was the warhead. Below the warhead there was a pressed cordite charge. The main body of the rocket consisted of the fuel tanks in two concentric tubes; the inner tube containing nitric acid, the outer tube, Visol. The tanks were closed not by valves but by metal membranes. To fire the *Typhoon* the cordite was discharged, the pressure built up by the charge ruptured the metal membranes and forced the fuels into the combustion chamber. The *Typhoon* was designed for very high acceleration; the take-off acceleration amounted to 31 *g* and was increased to 45 *g* by the time the fuel had been consumed.

The series of rockets code-named *Enzian* (*Gentian*) was also meant for antiaircraft fire from the ground. These rockets (there were four or five different types)

(*Concluded on page 306*)

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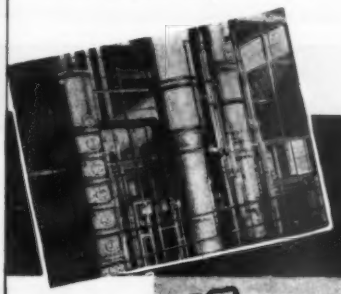

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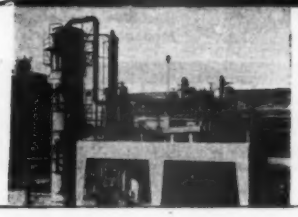

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TOO FEW, TOO LATE

(*Concluded from page 304*)

were also liquid fuel rockets, with solid fuel take-off booster. As rockets go, the *Gentian* was short and squat, with a diameter of three feet for a total length of 12.3 feet, weighing nearly 4,000 pounds at take-off. The high-explosive charge which it carried weighed 660 pounds. Unlike the *Typhoon*, the *Gentian* was intended to be a guided missile with radio control. None of the 24 rockets launched by January, 1945, was remotely controlled and only nine of the 24 were successful.

But the most fantastic of all German rocket devices was the one developed by Borsig-Rheinmetall. Since it was to be used in the Rhineland for aircraft interception, it was named *Rheintochter* (*Rhinemaiden*) or R-1. The *Rheintochter* was launched from an inclined ramp, and, to say the least, presented an extraordinary appearance. For the first two kilometers of its flight, the R-1 was carried by a booster unit, 22 inches in diameter and 58½ inches long. The end of the booster unit was covered with six rocket exhaust nozzles while four large slanting wings of mixed wood and metal construction projected from the booster unit in a cruciform pattern. The main rocket, only 20 inches in diameter and 11 feet, 10½ inches long, had four rather large wooden guiding fins near the nose and six long slanting wings, jutting out in a hexagonal pattern. Six rocket exhausts slanted out of the body between these wings, the only place left for them since the bottom of the main rocket, the section to which the booster unit was connected, was the bomb. The warhead was carried in the tail for a change.

Again counting from the nose or head, the arrangement of the parts was as follows: The nose contained a proximity fuse called *Kugelblitz* ("ball lightning") followed by four wooden control fins on the outside and their controlling motors on the inside. The next section contained the gyroscopes, followed by the compartment housing the radio receiver. Next came the fuel compartment and the six rocket exhausts, grouped between the six wings. The bottom compartment of the main rocket was the high-explosive charge. A guide flare was attached to its housing from the outside.

The multiplicity of fins and wings is somewhat hard to explain. Even when equipped with stabilizing fins, rockets have a tendency to rotate slowly. The numerous fins may have been intended to prevent, at all costs, a rotation of the rocket along its longitudinal axis. Another possible reason for the six long wings may have been to provide some lifting power by one pair of wings during horizontal, or near horizontal, movement, no matter in which position the rocket happened to be when the need for such movement arose. Most likely both of these purposes were in the minds of the designers when they put such an array of bristling wings and fins on the rocket.

The *Rhinemaiden* was to be guided from the ground by means of two correlated radar plots, one on the *Rhinemaiden* and one on the bomber to be destroyed.

None of all these weapons seems to have been used in combat by the Germans. Had the Nazis been given time to continue their work on these developments, one or more of these rockets may have turned out to be a rather effective weapon.

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A CENTURY OF SLEEP

(*Continued from page 280*)

In December, 1844, Horace Wells of Hartford, Conn., used nitrous oxide to produce anesthesia for tooth extraction, and during 1845 used ether once and nitrous oxide several times for the same purpose. Wells gave such information as he had to Morton with whom he had a brief partnership. When all is said the credit due Morton is not that of a discoverer but that of being the first to convince the world of the truth of the discovery. Wells made an attempt to promote the use of nitrous oxide, demonstrated it to Morton in Boston. In January, 1845, John Collins Warren permitted Wells to administer the gas to a boy for a tooth extraction before a class at the Harvard Medical School. Not enough gas was administered so that the boy screamed out in pain. Upon failure of this demonstration, the discouraged Wells returned to his home and abandoned his dental practice. Later, he went to Paris where he met little enthusiasm and was judged by many to be an impostor. Finally, after other experiences of frustration, he committed suicide in January, 1848.

The articles and papers of Long and Wells are listed and discussed in the *Annotated Catalogue*. So also are many of the ephemeral publications which relate to the Morton-Jackson controversy and other books and documents covering the whole history of anesthesia. The history of anesthesia is traced from the sleeping potions of the ancients, made from mandragora (or mandrake which we now know contains alkaloids of the scopolamine group), to opium, alcoholic intoxication, chilling the part with snow and ice-cold water (as was done by Avicenna early in the Eleventh Century and by the Russian surgeons of World War II), to carbon dioxide and to mesmerism, and on down to and including the establishment of chloroform and ether in general surgical practice. Regional and block anesthesia, and studies on individual anesthetics are more recent subjects reserved for Part II of the *Catalogue*.

Victory over Pain: A History of Anesthesia by Victor Robinson†† is a thoroughly scholarly work, with a selected and annotated bibliography and a useful index, attractively printed and illustrated, designed to be read. It is such a book as a book reviewer will read completely.

In 1920 Dr. Robinson founded *Medical Life*, the first monthly journal of medical history in the English language. Later the position of professor of the history of medicine in the Temple University Medical School was created for him — a position which he still occupies. His book treats very fully of the history of anesthesia and broadly of its cultural connections and implications. Starting with the drugs of the ancients — hellebore, dittany, opium, mandrake, lettuce, hemlock, henbane, mulberry, and hops — it follows the fight against pain in Europe as well as in America, and points out certain of its relationships to the fight against infection. It discusses improvements in obstetrics, the rise of aseptic and antiseptic surgery, and paints a realistic picture of the effects of pain, quoting in extenso from a letter describing his own experiences and reactions which "An Old Patient" (George Wilson) sent anonymously to Simpson of Edinburgh. The book supplies an easy and

(*Concluded on page 310*)

†† New York: Henry Schuman, 1946. xiv + 338 pages. $3.50.

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A CENTURY OF SLEEP

(*Concluded from page 308*)

agreeable way to orient oneself with respect to the new anesthetics, twilight sleep, continuous caudal analgesia, endotracheal, rectal, intravenous, spinal, and refrigeration anesthetics, ethylene, cyclopropane, divinyl ether, and curare. "At the present writing," says Robinson, "it is too early for curare to have a place in the textbooks of anesthesia, but it will be included in future editions. Curare, the horror drug of the forest, has been tamed by science and turned into a messenger of mercy." The story however is not wholly a triumphant one. Starting on the high note of victory over pain, it terminates with the tragic problems created by anesthesia itself:

> Death haunts the dental chairs and operating-rooms of America. Every year thousands of Americans needlessly die from preventable asphyxial accidents, a sad commentary after one hundred years of surgical anesthesia in the land of its birth.
>
> Continual training is needed by the doctors, dentists, nurses and technicians who bring the patient to the gates of sleep through anesthesia. Eternal vigilance is the price of safety in anesthesia. The ancient legend of Sleep as the twin-brother of Death gains a new meaning in the slumber of Anesthesia.
>
> Yet the portents are bright for the future. The days are past when anesthesia can be regarded as a mechanical and subsidiary adjunct of surgery, to be administered by hands that can be spared from other duties. The first centennial of anesthesia finds it emerging as a youthful and vigorous specialty.

This word of warning may well be proffered, particularly in these times when the number of properly trained medical personnel is sorely inadequate to meet current needs. Still, the scales are tremendously unbalanced in favor of the benefits which have come to mankind through the work of pioneers in anesthesia. Such must be the consensus of any review of a century of sleep.

NIGHT AERIAL PHOTOGRAPHY

(*Concluded from page 278*)

This article should not give the reader the impression that night photography and navigation are perfected developments. The present systems are not capable of accomplishing assigned missions as encountered in military situations except in favorable instances. The fundamental problems remain only partially solved. More development and experimentation are necessary, and are now in progress, to carry the methods to greater achievement. Perhaps perfect performance may never be attained.

Even the small success attained thus far would never have been possible were it not for the personal interest and co-operation given to the job by not only those directly engaged in the work here at M.I.T., but by the many persons in the services and in numerous industrial companies who gave unstintingly of their time and effort.

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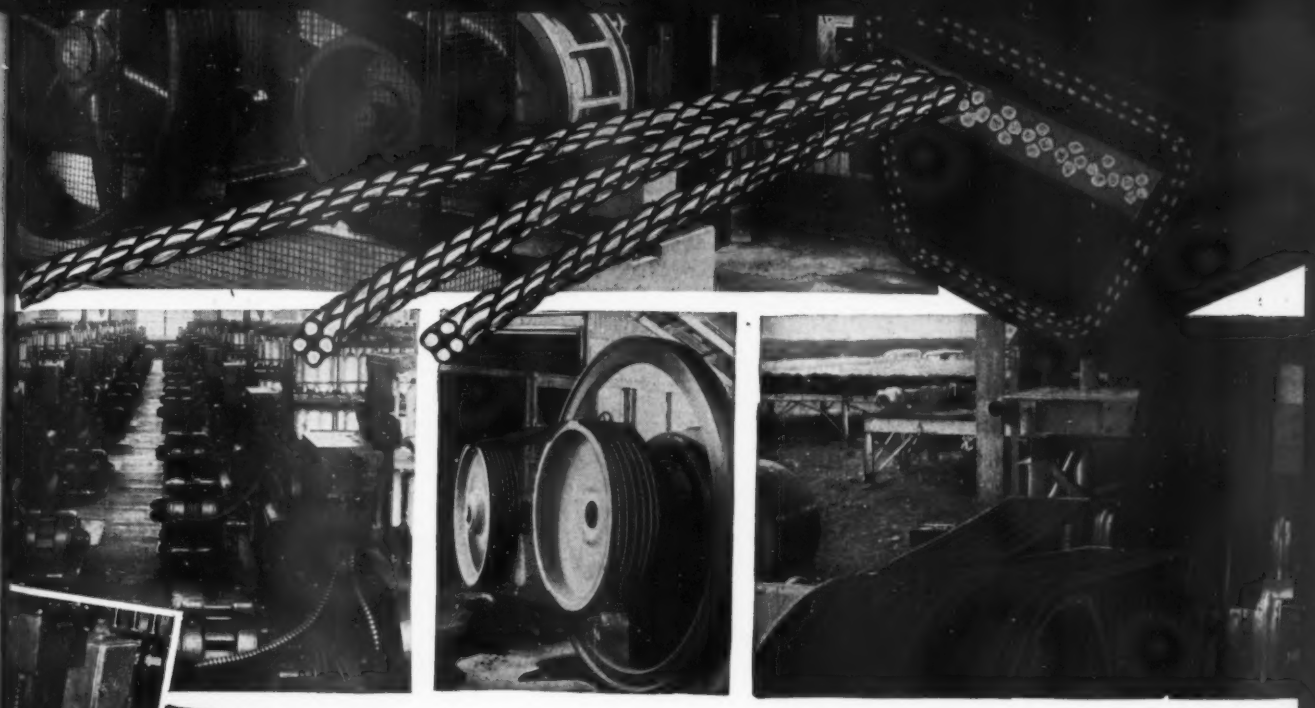

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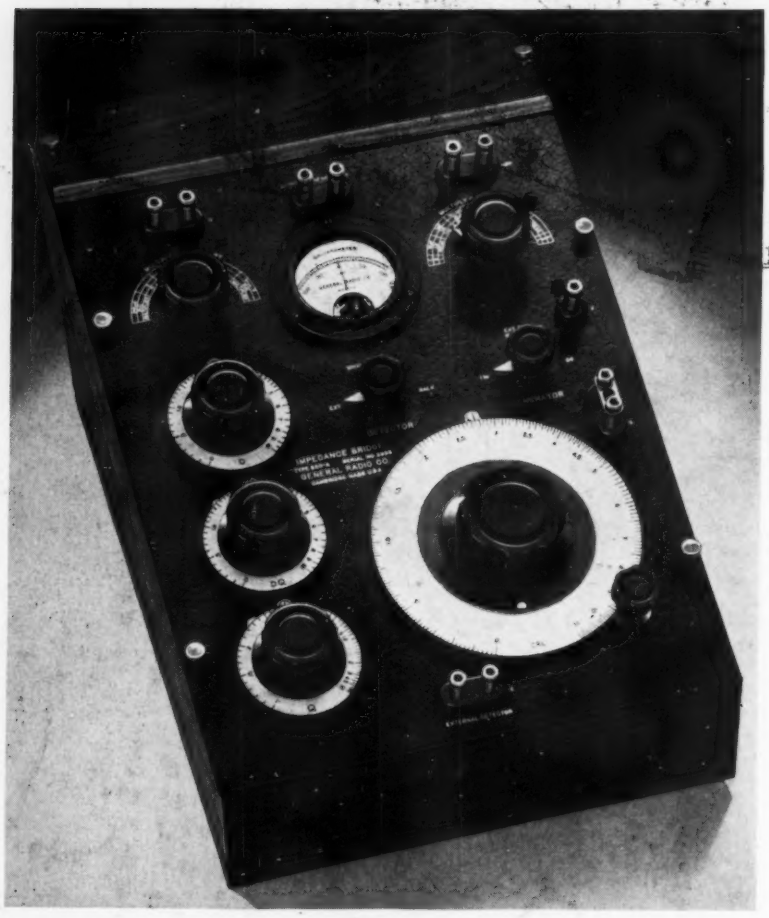

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